BUSINESS & PUBLICATION OFFICES
20TH AND NORTHAMPTON STREETS
EASTON, PENNSYLVANIA

EDITORIAL OFFICE
KENT CHEMICAL LABORATORY
THE UNIVERSITY OF CHICAGO

OTTO REINMUTH, *Editor*

VIRGINIA GORE, *Assistant to the Editor*
HARVEY F. MACK, *Business Manager*
CYRUS S. FLECK, *Assistant Business Manager*
B. F. GOULD, *Advertising Manager*
C. L. WELLS, *Circulation Manager*

BOARD OF PUBLICATION
T. L. DAVIS, G. J. ESSELEN, H. N. HOLMES, O. M. SMITH, N. W. RAKESTRAW

DEPARTMENTAL EDITORS
H. C. SHERMAN, *Graduate*
W. SEGERBLOM, *High School*
TENNEY L. DAVIS, *Historical*
R. E. ROSE, *Industrial*
M. M. HARING, *Undergraduate*

CONTRIBUTING EDITORS

G. A. ABBOTT	B. S. HOPKINS
B. H. BALL	J. W. HOWARD
A. P. BLACK	S. F. HOWARD
W. E. BRADT	S. W. HOYT
G. H. BRANDES	J. B. LUCAS
C. A. BRAUTLECHT	E. G. MAHIN
J. M. BRECKENRIDGE	R. N. MAXSON
B. S. BRONSON	R. K. MCALPINE
F. E. BROWN	W. MCCRORY
H. W. BRUBAKER	A. E. MCKINNEY
C. A. BUEHLER	J. P. MONTGOMERY
T. F. BUEHRER	H. W. MOSELEY
H. A. CARPENTER	L. ONCLEY
F. E. CLARK	A. M. PARDEE
J. D. CLARK	J. L. PARSONS
A. J. CURRIER	L. E. PORTER
F. B. DAINS	F. H. PRITTIE
L. C. DAVY	E. L. QUINN
N. DIETZ, JR.	G. R. ROBERTSON
O. C. DRAKE	W. F. RUDD
A. L. ELDER	H. SCHLUNDT
W. G. EVERSOLE	G. W. SEARS
O. R. FOSTER	O. F. STAFFORD
J. H. GRAHAM	R. E. SWAIN
G. C. GREENWOOD	A. P. SY
J. S. GUY	R. B. THOMPSON
W. A. HAMMOND	T. G. THOMPSON
E. B. HARTSHORN	R. G. TURNER
C. A. HASKEW	W. A. VAN WINKLE
C. C. HEDGES	B. A. VOIT
G. B. HEISIG	G. H. WHITEFORD
B. C. HENDRICKS	G. Y. WILLIAMS
H. N. HOLMES	L. F. WILLIAMS

FOREIGN EDITORS

F. LAMBERMONT, *Belgium*	N. PARRAVANO, *Italy*
W. LASH MILLER, *Canada*	WOJCIECH SWIETOSLAWSKI, *Poland*
F. G. DONNAN, *England*	ST. MINOVICI, *Roumania*
ATHERTON SEIDELL, *France*	SIR JAMES IRVINE, *Scotland*
K. FREUDENBERG, *Germany*	E. MOLES, *Spain*
ERNST COHEN, *Holland*	W. D. TREADWELL, *Switzerland*
H. RHEINBOLDT, *Brasil*	

Entered as second-class matter, January 31, 1924, at the Post Office at Easton, Pa., under the act of March 3, 1879. Accepted for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized January 31, 1924.

COPYRIGHT, 1938, BY DIVISION OF CHEMICAL EDUCATION, AMERICAN CHEMICAL SOCIETY

The JOURNAL OF CHEMICAL EDUCATION *is indexed in the Education Index, Industrial Arts Index, and, in part, in the Quarterly Cumulative Index Medicus*

JOURNAL OF CHEMICAL EDUCATION

for April, 1938

OFFICIAL MONTHLY PUBLICATION OF THE
DIVISION OF CHEMICAL EDUCATION OF THE
AMERICAN CHEMICAL SOCIETY

B. C. HENDRICKS, *Chairman*
N. W. RAKESTRAW, *Secretary*
M. V. MCGILL, *Vice-Chairman*
VIRGINIA BARTOW, *Treasurer*

Volume 15, Number 4 Contains

FRONTISPIECE—JOHANNES NICOLAUS BRØNSTED 151
EDITOR'S OUTLOOK 152
THE CHEMICAL CONTRIBUTIONS OF CHARLES HATCHETT 153
Mary Elvira Weeks
WHAT DO THE INDUSTRIES EXPECT OF THE COLLEGES? 159
John Xan
INDIANA HIGH-SCHOOL CHEMISTRY TEACHERS' CONFERENCE 160
TOUGH SOAP FILMS AND BUBBLES 161
Gerhard Albert Cook
APPARATUS FOR DETERMINING BOILING POINTS AND FREEZING POINTS OF SOLVENTS 166
E. E. Chandler
THE CHEMIST AT WORK 167
Roy I. Grady and John W. Chittum
I. THE PLANT CHEMIST 167
J. Alfred Hall
II. CHEMISTRY IN THE INSURANCE BUSINESS 169
Warren A. Hough
III. THE FIELD OF NUTRITION 172
Wm. E. Krauss
IV. THE CHEMIST IN THE LEAD-SILVER SMELTER 174
Franklin G. Hills
V. CHEMICAL RESEARCH IN THE GLASS INDUSTRY 175
William J. Arner
EXAMINATION PRACTICE IN GENERAL COLLEGE CHEMISTRY 176
B. Clifford Hendricks and Benjamin H. Handorf
A SATISFACTORY METHOD OF GENERATING HYDROGEN SULFIDE 179
V. T. Jackson and F. C. Suhrer
A PERIODIC SYSTEM OF THE ELEMENTS 180
E. C. Payne
HISTORICAL MATERIALS IN COLLEGE GENERAL CHEMISTRY TEXTBOOKS . 183
Ralph E. Dunbar
SOME SIMPLE EXPERIMENTS DEALING WITH RATES OF SOLUTION . . . 187
George W. Gleeson
COMBINATION FUNNEL SUPPORT AND BURET CLAMP 190
Philip S. Chen
A LABORATORY THERMOREGULATOR 191
Howard M. Waddle and Robert E. Imhoff
A SIMPLE METHOD OF CRYSTAL MODEL CONSTRUCTION 192
Keith M. Seymour
AIDS TO VACUUM DISTILLATION 194
Thos. S. Gardner
ABSTRACTS 195
RECENT BOOKS 198
TRADE ANNOUNCEMENTS XIV

Subscription Price: $3.00 per year; Canada $3.50; other countries $4.00. Single copies of issues in current year, 50c each; all other single copies, one dollar. Foreign remittances must be accompanied by International Money Order. Issued monthly.

No claims for copies of journals lost in the mails can be allowed unless such claims are received within sixty (60) days of the date of issue and no claims can be allowed for issues lost as a result of insufficient notice of change of address.

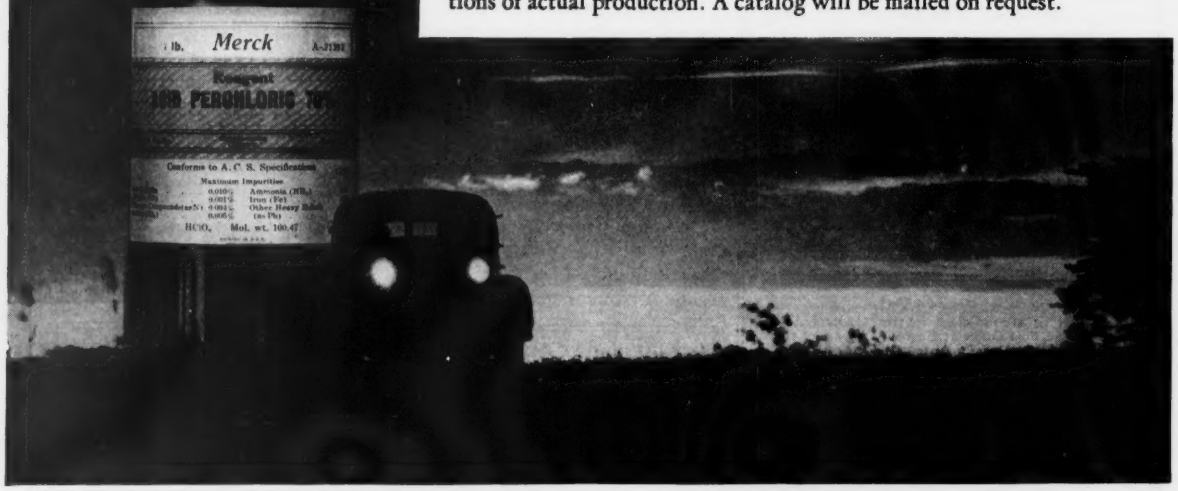
Manuscript for publication should be directed to the editor or to one of the departmental or contributing editors. Prospective authors are urged to avoid diffuse writing and to observe the forms outlined in our Notice to Authors of Papers as it appears on page 671 of the December, 1934, issue.

The CHEMISTRY *of the* AUTOMOBILE

Swift and silent—responding to every need for surging power to flatten hills and turn minutes into miles—the modern car takes in its stride a hundred demands which would have taxed the top performance of only a few years ago.

Yet, for the secret of its mechanical perfection, we must go far beyond the most carefully coordinated assembly line. Virtually every part of today's automobile is made of materials as carefully designed for a specific job as the part itself. This "designing" of special materials to exacting specifications is the actual starting point of your car's performance. Whether the material be an alloy of steel or other metal, a rubber or synthetic product, chemical reagents in the hands of skilled technicians played a vital part in its development.

For work of this exacting nature, research chemists rely on Merck Reagent Chemicals. Experience has shown that their purity and dependability are essential for uniform results, both in the laboratory and under the conditions of actual production. A catalog will be mailed on request.



MERCK & CO. INC. *Manufacturing Chemists* **RAHWAY, N. J.**

JOHANNES NICOLAUS BRONSTED (1879–)

Though J. N. Bronsted is probably most widely known for his fundamental contributions to the modern picture of acids, bases, neutral salt effect and related topics, these studies by no means constitute the only reasons for his international reputation as a physical chemist. Born at Varde, Denmark, on February 22, 1879, he received his higher education at the University of Copenhagen and has served his alma mater as professor since 1908. Students have come to him from many lands, particularly America, and a constant stream of papers has issued from his study and laboratory.

The main lines of his interests can be summarized: (1) studies of chemical affinity (thermodynamic theory of solutions, reactions in the solid state, allotropic and racemic transformations); (2) interaction theory of electrolytes (solubility of salts in salt solutions, theory of specific interaction, influence of medium); (3) separation of isotopes (with G. Hevesy); (4) protolytic theory of acids and bases, and of acid and basic catalysis (fundamental definitions of acids and bases, acid-base strengths in relation to charge and solvent, nitramide catalysis and other reactions subject to protolytic catalysis); (5) theory of reaction velocity in ionic systems, including experimental studies involving the theory of kinetic salt effect (primary and secondary); (6) thermodynamic properties in relation to molecular size, including colloidal and high-molecular phenomena; (7) general thermodynamics including a new system dealing with the relation between heat and work.

Dr. Bronsted was visiting professor at Yale in 1926; in 1928 he received the Orsted Medal; in 1930 he was made Director of the Physico-chemical Institute, created at Copenhagen by a grant from the International Education Board (Rockefeller Foundation). He has been honored by academies and learned societies; he is a member of the international "Committee on Science and Its Social Relations." His textbooks on inorganic and physical chemistry have been received with favor, and there will soon be available an English translation of his "Laerebog i fysisk Kemi."

(*Contributed by Ralph E. Oesper, University of Cincinnati*)

BOSTON UNIVERSITY
COLLEGE OF LIBERAL ARTS
LIBRARY

EDITOR'S OUTLOOK

FIRST AID TO VOCATIONAL COUNSELORS. We once knew an attractive woman who "loved flowers" and who sincerely believed herself to be a gardener at heart. The ribbons, medals, and cups she acquired from time to time at the local garden shows were among the most highly prized of her material possessions, and she could be induced to display and discuss them with a minimum of polite persuasion.

However, it did not take even the most rough-and-ready psychologist long to discover that she was in reality no gardener, but a scene designer, and a connoisseur of fragrant, impermanent *objets d'art*. In the garden, plants were to her lovely, but sometimes annoyingly capricious, stage properties. She could command skilled labor and expert technical advice, and she was intelligent enough to profit by them, but she never quite forgave the plants the fact that their unreasonable prejudices in the matters of light and shade, drainage, soil texture, and acidity or alkalinity vetoed or modified some of her cherished plans. Earth to her was dirt, and very dirty dirt at that, and she was more than content to leave its preparation and care to less sensitive souls. In the decorative garden she was an amateur landscape architect; in the cutting garden, a harvester. She sallied forth gloved and fetchingly attired, and she returned cool and immaculate with her spoils.

Now we submit that a true gardener would no more think of gardening in gloves than he would of washing his feet with his socks on. He (or she) rejoices in the feel of the soil, and his hands, grimy and calloused though they be, tell him almost as much as his eyes do. To him plants are living beings with lovable personalities, and he pampers them as he might a favorite grandchild. He suffers vicariously in their illness or malnutrition, and he hates all their natural enemies with a fierce intensity. He can use the knife or the pruning shears with a ruthlessness that appalls the uninitiated, but his chastisements are those of love.

It occurs to us that much of the hitherto existing literature on the science and profession of chemistry has been of a nature to attract recruits who are no more chemists at heart than our charming acquaintance was a gardener. The public in general, and many youthful students of the subject, are much better informed concerning the prizes, material and otherwise, it has yielded to its devotees and to society than they are concerning the problems and everyday activities of the average successful working chemist. Much that has been written of chemistry and chemists is insufficiently illuminating to the vocational counselor who is not himself a chemist, and some of it may prove actually deceptive to the student on the point of choosing a career. We were, therefore, glad to hear of the series of brief accounts proposed by Professors Grady and Chittum (see p. 167 *ff.*), and happy to encourage them in its compilation and preparation for publication.

In the nature of things, much of the world's work is carried on of necessity, or for gain, by people who are bored by, or actively dislike, their daily tasks. While this is perhaps to a considerable extent an unavoidable evil, it is, nevertheless, an evil. Such workers, as a rule, are not efficient, happy, or notably successful. If the present series plays any part in discouraging from a chemical career students who might otherwise be disillusioned too late, or in attracting to the profession any others who might otherwise find less satisfaction in a different field of endeavor, it will have served its purpose.

The CHEMICAL CONTRIBUTIONS *of* CHARLES HATCHETT

MARY ELVIRA WEEKS

University of Kansas, Lawrence, Kansas

UNLIKE most chemists, Charles Hatchett spent all his life in luxurious surroundings. He was born on January 2, 1765,* the son of a famous coach-builder of Long Acre, London, who in 1771 built at Chelsea a mansion called "Belle Vue House."[1,2,3]

Most of his scientific research was done during the decade 1796 to 1806. His first paper in the *Philosophical Transactions* described his analysis of the Carinthian lead molybdate.[4] "The celebrated Scheele," said he, "in 1778 read before the Academy of Sciences at Stockholm an essay in which he proved . . . that the mineral called *Molybdaena* was composed of sulfur and a peculiar metallic substance, which, like arsenic and tungsten, was liable by super-oxygenation to be converted into a metallic acid, which in its properties differed from any other that had been previously discovered." Hatchett mentioned the confirmatory researches of B. Pelletier, P. J. Hjelm, and "Mr. Islmann" [J. C. Ilsemann], and added, "But the existence of this substance was known to be only in that mineral which Scheele had examined." This lead mineral from Carinthia had been described by the Abbé F. X. Wulfen and by N. J. Jacquin. For several years it was believed to be lead tungstate, but Klaproth proved it to be lead molybdate. Since Klaproth had had an insufficient amount of the mineral, Hatchett made a complete analysis of it and investigated the properties of molybdic acid.

In the following year Hatchett was made a Fellow of the Royal Society. In 1798 he analyzed "an earthy substance," *sydneia*, which Josiah Wedgwood had found in New South Wales and another specimen of it provided by Sir Joseph Banks.[5] This, according to Wedgwood, was composed of "a fine white sand, a soft white earth, some colourless micaceous particles, and some which were black." Hatchett found it to consist "of siliceous earth, alumine, oxide of iron, and black lead or graphite" and concluded "that the Sydneian genus, in future, must be omitted in the mineral system."

(*From Faulkner's History of Chelsea, 1829*)
CHARLES HATCHETT, 1765–1847
ENGRAVING BY F. C. LEWIS AFTER THE PAINTING BY T. PHILLIPS

In the same year, he analyzed the water of the Mere of Diss.[6] Benjamin Wiseman of Diss, Norfolk, had no-

* Most authors state that Hatchett was born "in about 1765." The 1935 "Annuaire" of the Académie des Sciences, however, in its list of members and correspondents, gives the definite date, January 2, 1765. This annual gives the date of his death as March 10, 1847, instead of February 10.

[1] STEPHEN, LESLIE AND SIDNEY LEE, "Dictionary of national biography," Smith, Elder and Co., London, **1891**, vol. 25, p. 153. Article on Hatchett by Gordon Goodwin.

[2] Anonymous obituary of Charles Hatchett, *Gentlemen's Mag.*, n. s., **28**, 214–5 (Aug., 1847).

[3] FAULKNER, THOMAS, "A historical and topographical description of Chelsea and its environs," T. Faulkner, Chelsea, **1829**, vol. 1, pp. 89–92.

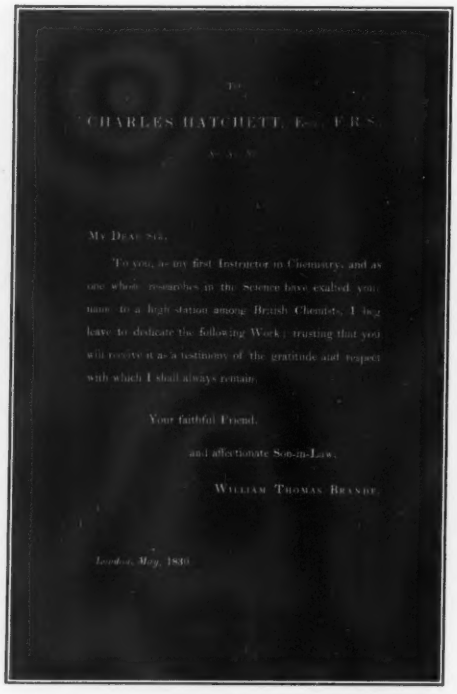
[4] HATCHETT, CHARLES, "An analysis of the Carinthian molybdate of lead...," *Phil. Trans.*, **86**, 285–339 (1796).

[5] HATCHETT, "An analysis of the earthy substance from New South Wales, called Sydneia, or terra australis," *Phil. Trans.*, **88**, 110–29 (1798); *Nicholson's J.*, **2**, 72–80 (May, 1798).

[6] HATCHETT, "Analysis of the water of the Mere of Diss," *Phil. Trans.*, **88**, 572–81 (1798); *Nicholson's J.*, **3**, 80–4 (May, 1799).

BOSTON UNIVERSITY
COLLEGE OF LIBERAL ARTS
LIBRARY

ticed that flint stones, calcareous spar, slate, and pottery left in this water from the summer of 1792 to August, 1795, acquired a metallic stain. He sent some of the water and some of the coated objects to the President and Council of the Royal Society, who forwarded them to Charles Hatchett for analysis. Although the deposit contained pyrite, the water, according to Hatchett, did "not hold in solution any sulphur and scarcely any iron; it has not therefore been concerned in forming the pyrites, but it appears to me that the pyritical matter is formed in the mud and filth of the Mere; for Mr. Wiseman says . . . that 'the Mere has received the silt of the


To
CHARLES HATCHETT, Esq. F.R.S.
&c. &c. &c.
My Dear Sir,
To you, as my first Instructor in Chemistry, and as one whose researches in the Science have exalted your name to a high station among British Chemists, I beg leave to dedicate the following Work; trusting that you will receive it as a testimony of the gratitude and respect with which I shall always remain
Your faithful Friend,
and affectionate Son-in-Law,
WILLIAM THOMAS BRANDE.
London, May, 1830.

Courtesy Franklin Institute
DEDICATION PAGE FROM BRANDE'S "MANUAL OF CHEMISTRY," THIRD EDITION, LONDON, 1830

streets for ages.' Now . . . sulphur is continually formed, or rather liberated, from putrefying animal and vegetable matter, . . . and this most probably has been the case at Diss. . ."

In the following year Sir Everard Home interested Mr. Hatchett in the chemical composition of dental enamel.[7,8] Since the tooth of the elephant is composed of three different structures, Sir Everard wished to know "whether the materials themselves were different or only differently arranged." Hatchett showed that the enamel was composed of calcium phosphate. "The enamel," said he, "has been supposed not a phosphate but a carbonate of lime. This error may have arisen from its solubility in acetous acid or distilled vinegar; but the effects of the acetous acid are in every respect the same on powdered bone as on the enamel."[8]

Hatchett then investigated the composition of shell and bone. "When it is applied to the cuttle-bone of the shops . . .," said he, "the term bone is here misapplied . . . for this substance in composition is exactly similar to shell, and consists of various membranes hardened by carbonate of lime, without the smallest mixture of phosphate."[8]

Mr. Hatchett observed that the external skeleton of crustaceans and the egg shells of birds contain more calcium carbonate than calcium phosphate, but that in bones the phosphate predominates. "It is possible," said he, ". . . that some bones may be found composed only of phosphate of lime; and that thus shells containing only carbonate of lime and bones containing only phosphate of lime will form the two extremities in the chain . . ."

In 1800 he published a paper which won the approbation and interest of Sir Humphry Davy.[9,10] "Mr. Hatchett," said he, "has noticed in his excellent paper on zoöphytes that isinglass is almost wholly composed of gelatine. I have found that 100 grains of good and dry isinglass contain more than 98 grains of matter soluble in water . . ." Dr. John Bostock (1774–1846) also praised this paper. "The term mucus," said he, "had been generally employed in a vague and unrestricted sense until Mr. Hatchett . . .attempted to assign to it a more appropriate and definite meaning. He conceives that jelly and mucus are only modifications of the same substance . . . he considers it to be entitled to the appellation of mucus when it is soluble in cold water and cannot be brought to a gelatinous state . . . the ideas which I have formed of the nature of jelly and mucus . . . differ materially from those of Mr. Hatchett. . . Mr. Hatchett . . . speaks of the white of the egg as consisting of pure albumen, but I believe that in this particular he will be found not perfectly accurate. . ." Dr. Bostock had found it to contain also a small amount of a substance incapable of coagulation.[11]

Soon after the turn of the century, Mr. Hatchett became interested in William Thomas Brande, a young apothecaries' apprentice who had recently moved to Chiswick. He encouraged the boy to collect and classify ores and rocks, and presented him with some of his duplicate specimens; the boy, in turn, sometimes assisted Mr. Hatchett in analyzing minerals.[1] Brande's first scientific paper was published in *Nicholson's Jour-*

[7] HOME, SIR EVERARD, "Some observations on the structure of the teeth of graminivorous quadrupeds. . ," *Phil. Trans.*, **89**, 243–7 (1799).

[8] HATCHETT, "Experiments and observations on shell and bone," *ibid.*, **89**, 315–34 (1799); *Nicholson's J.*, **3**, 500–6 (Feb., 1800); *ibid.*, **3**, 529–34 (March, 1800).

[9] HATCHETT, "Chemical experiments on zoöphytes," *Phil. Trans.*, **90**, 327–402 (1800).

[10] DAVY, SIR H., "An account of some experiments on the constituent parts of some astringent vegetables," *Nicholson's J.*, [2], **5**, 259 (Aug., 1803).

[11] BOSTOCK, JOHN, "Observations and experiments for the purpose of ascertaining the definite characters of the primary animal fluids. . ." *Nicholson's J.*, [2], **11**, 251, 254 (Aug., 1805).

nal when he was only sixteen years old. When he became Sir Humphry Davy's successor at the Royal Institution, Brande increased the mineral collection and used it in his lectures. He later married Charles Hatchett's daughter.

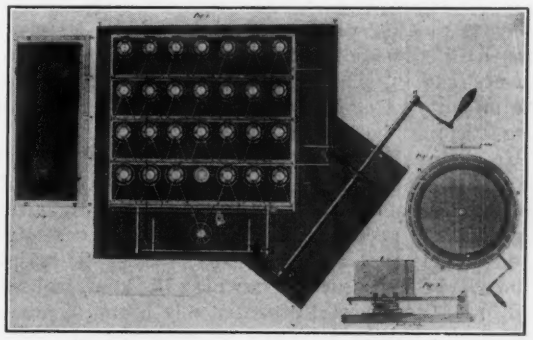
Hatchett's greatest achievement was probably his discovery of the metal columbium.[12] While he was arranging some minerals at the British Museum, one of them attracted his attention. From Sir Hans Sloane's catalog he found that it had been sent by "Mr. Winthrop of Massachusetts" [a grandson of the first governor of Connecticut].

Hatchett fused the ore with potassium carbonate. When he took up the melt with boiling water, a brown residue remained. When nitric acid was added to the yellow filtrate, a copious white precipitate was thrown down. "The preceding experiments shew," said he, "that the ore which has been analyzed consists of iron combined with an unknown substance and that the latter constitutes more than three fourths of the whole. This substance is proved to be of a metallic nature by the coloured precipitates which it forms with prussiate of potash and with tincture of galls; by the effects which zinc produces when immersed in the acid solutions; and by the colour which it communicates . . . to concrete phosphoric acid, when melted with it. . ." He mentioned that it retained oxygen tenaciously and that the oxide was acidic. Although the specimen Hatchett analyzed was very small, he hoped to get more soon from "a gentleman now in England (Mr. Smith, Secretary to the American Philosophical Society)." This was evidently Thomas P. Smith, who died in 1802. In his "Chemistry in America," Dr. Edgar Fahs Smith quotes from the *National Intelligencer*, "While we express our hopes that the whole history of this Columbian mineral will soon be made known, we sincerely deplore the afflicting and untimely death of our friend and countryman, Mr. Thomas P. Smith, from whose industry, acuteness and zeal in chemical . . . researches, Mr. Hatchett informs the Royal Society he had anticipated important aid in this inquiry."

Hatchett named the new metal *columbium* and stated that its "olive green prussiate and the orange-coloured gallate . . . may probably be employed with advantage as pigments." He also described his unsuccessful attempts to reduce the oxide to the metal. From his careful use of Lavoisier's new nomenclature, it is evident that Hatchett was not a phlogistonist.

In 1798 the Committee of Privy Council for considering the state of the coinage reported that the gold coin was suffering considerable losses in weight, and requested Henry Cavendish and Charles Hatchett to examine it "to ascertain whether this loss was occasioned by any defect."[13] Their experiments were begun near the end of 1798 and completed in April, 1801. At Cavendish's request the report was made by Hatchett alone. Hatchett stated, however, ". . . At all times I was favoured with his valuable advice; and the machines to produce friction, as well as the dies, were entirely contrived by himself. . ."

Hatchett studied the binary alloys of gold with arsenic, antimony, zinc, cobalt, nickel, manganese, bismuth, lead, tin, iron, platinum, copper, and silver, and confirmed the prevailing opinion that of these metals only copper and silver are suitable for alloying gold for coinage. He concluded "that gold made standard by silver and copper is rather to be preferred for coin. . ."



(*Phil. Trans., 1803*)

APPARATUS DESIGNED BY HENRY CAVENDISH AND USED BY CHARLES HATCHETT FOR DETERMINING THE COMPARATIVE WEAR OF GOLD WHEN ALLOYED BY VARIOUS METALS. TWO FRAMES, ONE ABOVE THE OTHER, EACH CARRYING TWENTY-EIGHT COINS, RUBBED THE UPPER COINS BACKWARD AND FORWARD OVER THE ONES BELOW. EACH OF THE SMALLER CONCENTRIC CIRCLES REPRESENTS A COIN. TO AVOID THE FORMATION OF FURROWS, THE DIRECTION IN WHICH THE COINS RUBBED AGAINST EACH OTHER WAS MADE TO VARY CONTINUALLY

and added that "there is commonly some silver in the gold which is sent to the Mint." He also stated, not without humor, that "our gold coin suffers but little by friction against itself; and the chief cause of natural and fair wear probably arises from extraneous and gritty particles; . . . the united effect of every species of friction to which they may be subjected, *fairly and unavoidably*, during circulation . . . will by no means account for the great and rapid diminution which has been observed in the gold coin of this country . . ." He added that the study of alloys had not kept pace with the rapid progress of chemistry and that "Few additions have been made to the compound metals employed by the ancients."

In 1804 he published an analysis of a "triple sulphuret of lead, antimony, and copper." James Smithson (1765–1829), founder of the Smithsonian Institution, disagreed with his conclusions. "It is not probable," said he, "that the present ore is a direct quadruple combination of the three metals and sulphur and that these,

[12] HATCHETT, "An analysis of a mineral substance from North America containing a metal hitherto unknown," *Phil. Trans.*, **92**, 49–66 (1802). Read Nov. 26, 1801. *Nicholson's J.*, [2], **1**, 32–4 (Jan., 1802).

[13] HATCHETT, "Experiments and observations on the various alloys, the specific gravity, and on the comparative wear of gold," *Phil. Trans.*, **93**, 43–194 (1803); *Nicholson's J.*, [2], **5**, 286–303 (Aug., 1803); *ibid.*, [2], **6**, 145–61 (Nov., 1803).

in their simple states, are its immediate component parts; it is much more credible that it is a combination of the three sulphurets of these metals. . ."[14,15]

At the same time Hatchett became interested in lac.[16] Geoffroy the Younger and J. A. C. Chaptal had regarded it as a kind of wax, but F. C. Gren and A. F. Fourcroy believed it to be a true resin. Hatchett concluded "that although lac is indisputably the production of insects, yet . . . the greater part of its aggregate properties, as well as of its component ingredients, are such as more immediately appertain to vegetable bodies . . ."

In 1804 he analyzed a strongly magnetic specimen of pyrite[17] to determine whether the magnetic polarity was inherent in the iron sulfide or whether minute particles of "the ordinary magnetical iron ore" [magnetite] were interspersed in it. Although he could find no previous mention of magnetic iron sulfide, Hatchett proved experimentally "that the three inflammable substances, carbon, sulphur, and phosphorus . . . possess the property of enabling iron to retain the power of magnetism . . ."

He continued the study of bitumens which he had begun in 1798 and strengthened the evidence "that bituminous substances are derived from the organized kingdoms of nature, and especially from vegetable bodies." He analyzed a "schistus"[18] which Sir Joseph Banks had found near a geyser near Reykum, Iceland, and found it to consist of water, oily bitumen, mixed gas, charcoal, silica, oxide of iron, and alumina.

When Sir James Hall (1761–1832) read of this work, he recalled his own experiments on "the effects of compression in modifying the effects of heat," and concluded that "the changes which, with true scientific modesty, he [Hatchett] ascribes to an unknown cause, may have resulted from various heats acting under pressure of various force."[19] Sir James subjected the theories of the geologists to the test of chemical experiment and showed that when limestone is heated under pressure, it is not converted into quicklime but into crystalline marble.

After analyzing some specimens from a pitch lake of Trinidad, Hatchett concluded that "a considerable part of the aggregate mass at Trinidad was not pure mineral pitch or asphaltum, but rather a porous stone of the argillaceous genus, much impregnated with bitumen." The specimens he analyzed, however, were not representative of the lake as a whole."[20]

In 1804 William Nicholson, the editor, chose Mr. Hatchett and Edward Howard to serve with him on a committee to judge Richard Chenevix's alloy of platinum and mercury which Chenevix believed identical with palladium, the new metal which had been announced anonymously by W. H. Wollaston. Hatchett saw with his own eyes some of the experiments made by the enthusiastic but misguided Chenevix.

During the years 1805 and 1806 Hatchett published three papers on an artificial tanning agent.[21] He mentioned the researches of Nicolas Deyeux (1753?–1837), Armand Séguin (1765?–1835), and Sir Humphry Davy on the natural tanning agents, and added that R. Chenevix had "observed that a decoction of coffee-berries did not precipitate gelatine unless they had been previously roasted; so that tannin had in this case either been formed or had been developed from the other vegetable principles by the effects of heat."

Hatchett treated various kinds of wood, coal, and coke with nitric acid, and found that "a substance very analogous to tannin . . . may at any time be produced by exposing carbonaceous substances, whether vegetable, animal, or mineral, to the action of nitric acid." He also "converted skin into leather by means of materials which, to professional men, must appear extraordinary, such as deal sawdust, asphaltum, common turpentine, pit-coal, wax candle, and a piece of the same sort of skin . . ."

Dr. John Bostock tried unsuccessfully to use Hatchett's artificial tan as a test for "jelly" [gelatine]. Although it had been stated "on the highest authority, that of Mr. Hatchett and Mr. Davy . . . that isinglass consists of nearly pure jelly," Dr. Bostock found that isinglass from the shops contained a certain amount of insoluble matter, which he believed to be coagulated albumen. Dr. G. Melandri of Milan also investigated Hatchett's tannin.

M. E. Chevreul, near the beginning of his surprisingly long career, studied Hatchett's papers and prepared some of the "tannin." Hatchett had found that pit-coal which contained no resinous substance was dissolved completely by nitric acid and converted into the artificial tannin, whereas any resinous matter remained undissolved. When Chevreul treated pit-coal with nitric acid, however, evaporated the solution, and poured it into water, "a yellow matter separated, which was much more abundant than what remained in solution, and had no property that rendered it similar to resins . . . yet I do not allow myself," said Chevreul, "the least reflection on the labours of that celebrated English

[14] HATCHETT, "Analysis of a triple sulphuret of lead, antimony and copper from Cornwall," *Phil. Trans.*, **94**, 63–9 (1804).

[15] SMITHSON, JAMES, "On the composition of the compound sulphuret from Huel Boys...," *Nicholson's J.*, [2], **20**, 332–3 (Suppl., 1808).

[16] HATCHETT, "Analytical experiments and observations on lac," *Phil. Trans.*, **94**, 191–218 (1804); *Nicholson's J.*, [2], **10**, 45–55 (Jan., 1805); *ibid.*, [2], **10**, 95–102 (Feb., 1805).

[17] HATCHETT, "An analysis of the magnetical pyrites; with remarks on some of the other sulphurets of iron," *Phil. Trans.*, **94**, 315–45 (1804); *Nicholson's J.*, [2], **10**, 265–76 (Apr., 1805); *ibid.*, [2], **11**, 6–17 (May, 1805).

[18] HATCHETT, "Observations on the change of some of the proximate principles of vegetables into bitumen; with analytical experiments on a peculiar substance which is found with the Bovey coal," *Phil. Trans.*, **94**, 385–410 (1804); *Nicholson's J.*, [2], **10**, 181–200 (March, 1805); *ibid.*, **2**, 248–53 (Sept., 1798).

[19] HALL, SIR JAMES, "Account of a series of experiments showing the effects of compression in modifying the effects of heat," *Nicholson's J.*, [2], **14**, 118 (June, 1806); *ibid.*, [2], **14**, 201–2 (July, 1806).

[20] NUGENT, NICHOLAS, "Account of the Pitch Lake of the Island of Trinidad," *ibid.*, [2], **32**, 209 (July, 1812).

[21] HATCHETT, "On an artificial substance which possesses the principal characteristic properties of tannin," *Phil. Trans.*, **95**, 211–24, 285–315 (1805); *ibid.*, **96**, 109–46 (1806); *Nicholson's J.*, [2], **12**, 327–31 (Suppl., 1805); *ibid.*, [2], **13**, 23–36 (Jan., 1806); *ibid.*, [2], **15**, 15–31 (Sept., 1806); *ibid.*, [2], **15**, 86–98 (Oct., 1806).

chemist, as I am too fully aware that different modes of operating and the different varieties of the bodies examined . . . may produce a variation in the results . . ." Chevreul found that the water-soluble substance which precipitated gelatine copiously was a compound of nitric acid and carbonaceous matter . . ."[22] These artificial tannins have since been identified as picric acid and other nitro derivatives of phenols.[23]

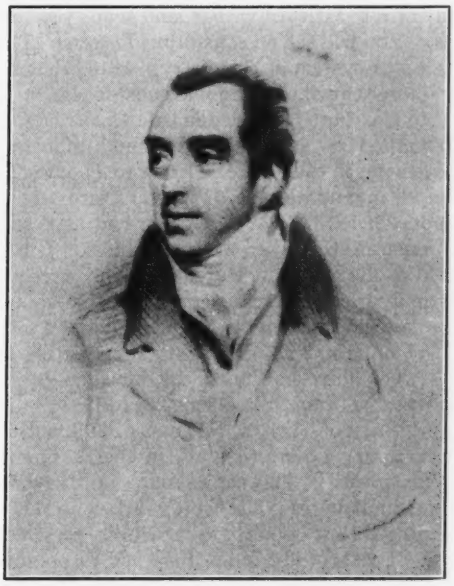
Thomas Thomson said in 1810, "Till lately the analysis of vegetable substances was almost entirely overlooked by British chemists; but the fineness of the field has now begun to attract their attention. Experiments of great importance have been published by Davy, Chenevix &c and above all by Hatchett . . ."[24]

On February 21, 1809, Hatchett became a member of the famous Literary Club which had been founded in 1764 by Dr. Samuel Johnson and Sir Joshua Reynolds. As treasurer of the club, Hatchett prepared a brief historical account of it, which appears in Boswell's "Life of Johnson."[25] The club also included, among others, Edmund Burke, Oliver Goldsmith, David Garrick, Edward Gibbon, Adam Smith, Sir Joseph Banks, Sir Charles Blagden, Sir Humphry Davy, Dr. W. H. Wollaston, Sir Walter Scott, Sir Thomas Lawrence, and Dr. Thomas Young.

Hatchett also took an active part in the *Animal Chemistry Club*, which met alternately at his home and that of Sir Everard Home. Once every three months, Sir Benjamin Brodie, Sir Humphry Davy, W. T. Brande, Mr. John George Children, and a few others dined with the two hosts and discussed their researches in physiological chemistry.[26,27,28] According to Sir Benjamin Brodie, "they were very rational meetings, in which a good deal of scientific discussion was mixed up with lively and agreeable conversation. The society continued to exist for ten or eleven years, but during the latter part of the time, some other members were added to it, and it degenerated into a mere dinner club . . . Hatchett, who had now inherited a considerable fortune on the death of his father, had ceased to work in chemistry (in spite of the remonstrance of Sir Joseph Banks, who used to say to him in his rough way that 'he would find being a gentleman of fortune was a confounded bad trade'), but he had previously laid up a large store of knowledge, abounded in the materials of conversation, and was a delightful companion . . ."[28]

Hatchett was one of the "educated men, with the sagacity for which this nation is famous" who helped to entertain Berzelius in 1812.[29] Since Berzelius understood little of what the English chemists were saying, he had a dull time at Hatchett's dinner party. It was there, nevertheless, that he first made the acquaintance of Dr. Alexander Marcet.

In his travel diary Berzelius wrote, "Hatchett himself is a very agreeable man of about forty to forty-five years. His father was a rich coachmaker, and the son, although a famous chemist at the time of his father's death, has continued to carry on the business. He is in very good circumstances, and lives in Roehampton on a little estate built in a fine Italian style and excellently maintained . . . Close by his Italian villa he has a very well-equipped laboratory, but for a long time he has not worked."[30]



CHARLES HATCHETT
THIS PORTRAIT WAS LITHOGRAPHED BY DAY AND HAGHE FROM THE PAINTING BY THOMAS PHILLIPS, AND PUBLISHED IN 1836 BY THOMAS MCLEAN

When the English translation of Berzelius' treatise on the composition of animal fluids appeared, Dr. Marcet wrote, "Your great memoir is an honour to us. Hatchett, however, complains that, when you hunted in his

[22] CHEVREUL, M. E., "Tanning substances formed by the action of nitric acid on several vegetable matters," *Nicholson's J.*, [2], **32**, 360–74 (Suppl., 1812); *Ann. chim. phys.*, [1], **73**, 36–66 (1810).

[23] WOLESENSKY, EDWARD, "Investigation of synthetic tanning material," Bureau of Standards Technologic Paper No. 302 (1925), pp. 6–7.

[24] THOMSON, THOMAS, "A system of chemistry," 4th ed., Bell and Bradfute, Edinburgh, **1810**, vol. 5, p. 180.

[25] BOSWELL, JAMES, "Life of Samuel Johnson, LL.D.," edited by J. W. Croker, George Bell and Sons, London, **1876**, vol. 2, pp. 325–9.

[26] HOLMES, TIMOTHY, "Sir Benjamin Collins Brodie," T. Fisher Unwin, London, **1898**, p. 46 and pp. 61–2.

[27] Anonymous obituary of W. T. Brande, *J. Chem. Soc.* (London), **19**, 509–11 (1866).

[28] HAWKINS, CHARLES, "The works of Sir Benjamin Collins Brodie, with an autobiography," Longman, Green, Longman, Roberts, and Green, London, **1865**, vol. 1, pp. 55–8.

[29] SÖDERBAUM, H. G., "Jac Berzelius Bref," Almqvist & Wiksells, Upsala, **1912–1914**, vol. 1, part 1, p. 42. Berzelius to Berthollet, Oct., 1812; *ibid.*, vol. 1, part 3, p. 19. Marcet to Berzelius, Jan. 25, 1813; *ibid.*, p. 45. Marcet to Berzelius, May 5, 1813; *ibid.*, p. 58. Berzelius to Marcet, June 30, 1813; *ibid.*, p. 66. Marcet to Berzelius, July 28 and Aug. 4, 1813; *ibid.*, p. 183. Marcet to Berzelius, Dec., 1818; *ibid.*, pp. 231–2. Marcet to Berzelius, Jan. 15, 1822.

[30] BERZELIUS, "Reseanteckningar," P. A. Norstedt & Söner, Stockholm, **1903**, pp. 23–4, 29, and 38.

grounds, you didn't even cite him; but I have explained to him, as best I could, the haste in which you found yourself and your necessity of abstaining from reference work."

"I am very sorry," replied Berzelius, ". . . . but if you take this matter up with him again, tell him that I am absolutely ignorant of any other work of his on these subjects than that of the testaceae. . ." Berzelius also explained that he had confined himself almost entirely to a description of his own work. Dr. Marcet replied, "I gave your little compliment to Hatchett, who seemed entirely satisfied with it, and sends you his best regards. You will see on consulting *Thomson* [Thomas Thomson, "A system of chemistry," 1810] that he has written more than once on animal substances."[29]

In 1813 Hatchett published in the *Annals of Philosophy* a method of separating iron and manganese.[31] This paper was in the form of a letter to Thomas Thomson, the editor, and was dated "Mount Clare, Roehampton, Sept. 25, 1813." A. F. Gehlen had used succinic acid to separate these two metals, Professor J. F. John had used oxalic acid, but Hatchett simply precipitated the ferric hydroxide from a neutral solution containing ammonium chloride, leaving the manganese in solution.

In 1817 he described a method of renovating musty "corn" [wheat] by floating off the damaged grain with boiling water and carefully drying the rest.[32]

In his history of Chelsea,[33] Thomas Faulkner has left a contemporary description of Hatchett's fine home, Belle Vue House. "This capital mansion," says Faulkner, "was built by Mr. Hatchett's father in 1771; and the weeping willow opposite to the house, reckoned one of the finest trees of its kind in England, was planted by him in 1776; it commands beautiful views of the Thames and the distant Surrey Hills." In the house were paintings by several great masters, a portrait of Mrs. Hatchett by Gainsborough, a large organ, a collection of manuscript and printed music, and some Mongol idols collected by Hatchett's friend Peter Simon Pallas, the famous traveler. "The library," said Faulkner, "is extensive, and contains many valuable editions of the Greek and Latin Classics, together with a numerous series of Historical Works, and the voluminous Transactions and Memoirs of the Royal Society and other similar learned Institutions of Europe."

In December, 1818, Dr. Marcet wrote to Berzelius, "Wollaston, [Sir William] Congreve, and Hatchett are hard at work, but up to the present haven't produced anything." Three years later he wrote: "Hatchett is taking care of his money and paying court to personages with grand titles; but is no longer doing anything in chemistry, and I do not even know that he is showing much interest in what others are doing."[29] He must have retained some interest, however, for on September 15, 1823, he was elected as a correspondent for the chemical section of the *Académie des Sciences*. In 1836 Hatchett published a quarto brochure on "The spikenard of the ancients." He died at his home, Belle Vue House, Chelsea, on February 10, 1847, at the age of eighty-two years.

In 1821 the Reverend J. J. Conybeare (1779–1824) named an Australian mineral in honor of "the eminent chemist to whom we are indebted for the most valuable contributions towards the history and analysis of this class of mineral substances"; this form of mineral tallow is still known as *hatchettine* or *hatchettite*. He found later, however, that it was identical with the substance W. T. Brande had referred to as *mineral adipocere*.[34]

In 1877 the American mineralogical chemist J. Lawrence Smith named a mineral from North Carolina, a columbate of uranium, *hatchettolite*, because Hatchett's discovery of columbium "was clear, precise, and well made out, and has never been controverted."[35]

[31] HATCHETT, "On the method of separating iron from manganese," *Annals of Philos.*, **2**, 343–5 (Nov., 1813); J. F. JOHN, *ibid.*, **2**, 172–3 (Sept., 1813).

[32] HATCHETT, "A description of a process by which corn tainted with must may be completely purified," *Phil. Trans.*, **107**, 36–8 (1817). Letter to Sir Joseph Banks.

[33] FAULKNER, THOMAS, "A historical and topographical description of Chelsea and its environs," T. Faulkner, Chelsea, **1829**, vol. 1, pp. 89–92.

[34] CONYBEARE, J. J., "Description of a new substance found in ironstone," *Annals of Philos.*, **17**, 136 (Feb., 1821); *ibid.*, **21**, 190 (March, 1823).

[35] SMITH, J. LAWRENCE, "Examination of American minerals. No. 6.—Description of columbic acid minerals from new localities in the United States, embracing a reclamation for the restoration of the name columbium to the element now called niobium . . .," *Am. J. Sci.*, [3], **13**, 359–69 (May, 1877).

By cherishing as a vital principle an unbounded spirit of inquiry, and ardency of expectation, it unfetters the mind from prejudice of every kind and leaves it open and free to every impression of a higher nature, which it is susceptible of receiving, guarding only against enthusiasm and self-deception by a habit of strict investigation, but encouraging rather than suppressing everything that can offer a prospect or a hope beyond the present obscure and unsatisfactory state. The character of the true philosopher is to hope all things not impossible, and to believe all things not unreasonable. He who has seen obscurities which appeared impenetrable in physical and mathematical science suddenly dispelled, and the most barren and unpromising fields of inquiry converted, as if by inspiration, into rich and inexhaustible springs of knowledge and power on a simple change of our point of view, or by merely bringing to bear on them some principle which it never occurred before to try, will surely be the very last to acquiesce in any dispiriting prospects of either the present or future destinies of mankind . . . . —SIR JOHN HERSCHEL

WHAT DO *the* INDUSTRIES EXPECT *of the* COLLEGES?*

JOHN XAN

Howard College, Birmingham, Alabama

THIS question is difficult and fundamental. It strikes at the roots of our educational system, and it challenges the purpose and product of our schools and colleges. I felt that I was not qualified to prepare a paper answering such a question, so I went for help directly to the men who are vitally interested in and dealing with this problem continuously. Several executives of industrial concerns in the Birmingham district have been interviewed. Their ideas and recommendations make up the largest part of this paper.

These busy men were courteous and generous with their time, and, above all, very interested and coöperative. Two or three have allowed me to read confidential reports, and copies of lectures they gave before students in different colleges. Others gave me complimentary copies of articles published in different journals on the same question applied to special fields.

The industries look to the colleges for two things: (1) a certain type of graduate, and (2) cultural background and coöperation in some special problems.

TYPE OF GRADUATE

The colleges certainly would have great difficulty in turning out a graduate who would meet all the requirements mentioned by the different executives. They described a man who is a combination of Roosevelt, Compton, and E. Stanley Jones. Only a superhuman being can have the personality of Roosevelt, the technical knowledge and ability of Compton, and the religious and spiritual qualities of E. Stanley Jones.

Students as I know them do not measure up to such standards. Only a few can remotely approach them. Yet the institutions of learning are expected to imbue these students with all these qualities, a Herculean task.

The colleges, however, can develop the students' character, can help them acquire certain qualifications, and can instil in them certain attitudes.

Character.—Arthur E. Morgan, former president of Antioch College and now one of the directors of TVA defines character[1] as follows, "Character is the coördination of two factors.

"First, character is that condition of personality which expresses itself in consistently sustained habit of using one's whole resources with courage, decision, and persistence in accordance with one's best judgment. When I say *conditions of personality* I mean condition of nerves, muscles, brain tracks and entire habit pattern which tends to determine the type of action.

"Second, character is the slowly acquired possession of values, purposes, convictions, appraisals, judgments, discriminations, tastes, and loyalties which are in accord with the actual nature of things and with the welfare of life in general."

This is a very inclusive definition, and it fits the type of character the executives said that the college graduate should have. In actual cases, however, we find every kind and degree of combinations of the various elements of character. The job of the institutions is to try to develop them to the fullest degree and in the best proportion so that a college graduate will be able to get along with all classes of people and have respect for the worth of the individual. Honesty, dependability, resourcefulness and accuracy, *self-control* and pleasing personality should be developed in accordance with the natural abilities of the student. All the colleges can do is to improve the habit pattern of the material they get.

I believe that the character of a college student can be improved or made worse by his experiences in industry. The executives, superintendents, foremen, or other leaders in industry are responsible for the further development of those elements of character which they desire. Thus, they can supplement and direct the character development of the graduate in any direction that is needed to meet the demands of the specific job they have in mind for him.

Qualifications.—The ideal graduate as described by one of the men interviewed is a young man outstanding in grades as well as college activities, of broad scientific and philosophical vision. As to the relative importance of grades and participation in college activities, opinions vary, but all want to see at least average grades. A good foundation in English, especially speaking, writing, and spelling, is considered imperative. Good ground work in mathematics, chemistry, physics, and a liberal arts background including such subjects as economics, practical psychology, sociology, history, literature, management of labor, and even Bible is essential. As to technical training employers would like some work in the industrial process in general, but they prefer to teach their specific processes. If the training is scientifically sound and fundamentally basic,

* Presented before the Industrial Chemistry section of the Alabama Academy of Science at the Spring Meeting, 1937.

[1] This definition is given in a confidential report to one of the large concerns in the city of Birmingham.

the graduate can be placed in a position fitted to his temperament and inclination.

Obviously, the training which has been described cannot be accomplished in our ordinary conventional four-year college course. The technical courses are too crowded and too hastily covered during this specified time. The students need time to digest the material. They cram to get through, and, as a result, the educational product is not what industries expect. The cultural background required cannot be obtained in one or two courses in English but in contact with a cultural environment for four years. Culture is not mere knowledge of English literature or ability to enjoy the best writers, but a technic in dealing with our fellow men and enough knowledge to be able to discuss intelligently other subjects besides one's specialty, avoiding barbarous language and using good grammar, fine diction, and interesting expression.

Since the above cannot be done adequately in the four-year conventional technical course, a modification is needed. The industries can help in this. They should offer a graduate course as a transition period in which the student comes in direct contact with the problems of industry. Here he should learn to operate machines, obey orders, prepare himself for a job in industry. The cultural background he has had, and he will be getting the practical knowledge. In chemical engineering, for instance, the students cover a five-year course in four years. How much better training the students would have if they spent five years to cover the same ground, with the fifth year as the transition period in contact with industry.

During the four years the student should be taught to understand human nature and learn how to control men. He should acquire love for study, not only in the plant but also at home, reading technical journals and keeping abreast of his field.

Attitudes.—The fundamental desirable attitude is that his education and his special training are only tools which enable him to learn faster from superiors or inferiors. No job should be too menial. He must be willing to start at the bottom for the purpose of learning, and not for teaching or finding faults. He must enter industry with an humble spirit and learn the system before he makes any criticism to the authorities. He must realize that many years of experience are involved in the particular process he is about to criticize. He should be willing and anxious to learn things for himself before he is able to direct others. The executives say in this connection, "The more direction you require, the less pay you get." A pull may get him a job, but only ability and proper attitudes will enable him to keep it.

Colleges can instill in their graduates these attitudes but industry alone can develop them. This training can be easily started during that fifth transitional year, becoming more firmly fixed as the years pass.

When a candidate is presented, the executives ask themselves, as they look him over, "What will be the ultimate destiny of this man as a salesman, as an engineer, as a technical research man, as an operator, or as a plant superintendent?" When they have determined where he fits they ask further, "Will he also make a good executive?" These questions can be partially answered by the candidate himself during that fifth transitional period in contact with the industry.

CULTURAL BACKGROUND AND COÖPERATION IN SPECIAL PROBLEMS

The second part of this paper does not represent the opinions of all of the executives interviewed. The majority were hesitant to express a definite opinion as to whether the college should provide a cultural background for the general employees and coöperation in some special problem. What cultural background can the colleges provide? Since their faculties are composed of men of special training in various fields, they should be able to give popular lectures, thus giving the average layman an idea of what is going on in the world. Some industries, I was told, do provide such lectures. Why should the college specialists not give them?

In addition the faculties should show willingness to coöperate in specific problems requiring very expert knowledge in such fields as higher mathematics, or in the translation of foreign articles. I do not mean consultation work, but a voluntary and spontaneous desire on the part of the college faculty to help industry keep its employees informed, solve sporadic and knotty problems, and generally coöperate in making an industrial community a better place in which to live.

INDIANA HIGH-SCHOOL CHEMISTRY TEACHERS' CONFERENCE

The Indiana High-School Chemistry Teachers' Association will meet at Indiana State Teachers' College, Terre Haute, Ind. April 15 and 16, 1938. Officers of the Association for the current year are: Edward Zetterberg, Muncie, President; Hubert Rice, Vincennes, Vice-president; June Ossenberg, Martinsville, Secretary-Treasurer.

PROGRAM

Friday, April 15th

A.M. Visits to Rose Polytechnic Institute; Garfield, Gerstmeyer, Wiley, or Laboratory High Schools

P.M. Need for a Better Balanced Curriculum as Affecting High-School Science Courses—Kenneth E. Conn, Bloomington
Experiment to Show that Metals Replace Hydrogen in Proportion to Their Valences—F. B. Wade, Indianapolis
Practical Science as a Substitute for Chemistry—June E. Ossenberg, Martinsville
Results of Mathematical Tests in Chemistry—W. C. Geisler
Polaroid Equipment—L. I. Steinbach, Chicago Apparatus Co.

EVENING. Dinner in honor of Professor Edwin M. Bruce, retired professor of chemistry at Indiana State Teachers' College. William N. Bell, *Chairman*
Address (tentative)—Dr. R. E. Lyons, Indiana University
Erpi Classroom Instructional Sound Films

Saturday, April 16th

A.M. Dry Ice as a Source of Carbon Dioxide in the Solvay Experiment—Allan R. Stacy, Indianapolis
The Origin of a Science Mural—Robert L. Black, Indianapolis
Basic Training and Requirements of Technical Education—Professor Ralph K. Strong, Rose Polytechnic Institute, Terre Haute
Chemistry and Biology as the Foundation of Medical Education in Indiana—James H. Brayton, Indianapolis
A Project in Fractional Distillation—Richard Martz and Charles Good, Students of Lois Martin, Indianapolis
Useful Chemical Charts and Demonstration Apparatus—Druley Parker, Indianapolis

P.M. Trip through the Commercial Solvents Factory

TOUGH SOAP FILMS *and* BUBBLES

GERHARD ALBERT COOK*

Case School of Applied Science, Cleveland, Ohio

THERE is a well-known lecture demonstration in which soap bubbles are blown with a mixture of hydrogen and oxygen. When the bubbles have broken away from the pipe, and have risen to a safe distance from it, they are ignited. The chief practical problem involved in this experiment is to make certain that the soap bubbles leave the pipe without rupturing and have a sufficiently long lifetime to stay intact till ignited. It was this problem that first interested the writer in the subject of long-lived bubbles. There are, however, many other lecture experiments that may be performed, illustrating various principles of chemistry and physics, involving the same problem; and long-lived soap films have also found application in engineering research† on the torsional stresses, and the distribution of stresses, in beams and other structural members of aircraft, bridges, machines, etc. This is because of a mathematical analogy between the torsion or stress of the member, and that of a membrane (such as a soap film) subjected to an excess of pressure on one side, as by compressed air.

REVIEW OF THE LITERATURE

In setting out to prepare a suitable soap solution for lecture work, one naturally turns first to such commonly available reference books as Benedict's "Chemical Lecture Experiments" and the handbooks. Benedict (*1*, p. 52) and Hodgman (*2*, p. 1909) give somewhat similar directions. Benedict recommends saturating a liter of water with Castile soap, letting it stand, decanting off the clear liquid and adding half its volume of glycerine. Such a solution, made without any special precautions, often gives bubbles that are too weak for satisfactory lecture work, and films made from it have only a very short lifetime.

N. A. Lange's "Handbook of Chemistry" (1937) makes no mention of how to prepare soap solutions to be used in bubble or film making.

On looking further in the literature, one finds that there are two excellent books, both published originally in England, devoted entirely to the problem at hand. The older of these is by C. V. Boys (*3*). It is full of descriptions of experiments, instructive and interesting, that may be carried out with soap bubbles, and it gives a discussion of the difficulties of preparing suitable soap solutions, and methods for overcoming them. Boys ascribes the principal difficulty in the use of Castile soap solutions to the fact that whereas Castile soap used to be made from olive oil, nowadays the oil from which it is made is usually mixed with cottonseed oil. He recommends as the solution he found most satisfactory, a slightly less than two per cent. solution of pure sodium oleate made by dissolving the soap in water, adding one-third its volume of glycerine, letting the mixture stand in the dark, and then siphoning off the clear liquid, and adding one or two drops of concentrated ammonia per pint of solution. The solution must never be warmed nor filtered. It is kept in a dark place and opened only when necessary.

Boys also (*3*, p. 113) briefly describes bubbles blown from other liquids than soap solutions, of which the most interesting are the "surprising and ludicrous" saponin bubbles, which do not contract evenly when the air is removed from inside them, but become puckered.

More recent is the volume by Lawrence (*4*), which is quite up to date and presents an excellent review of the classic work of Sir James Dewar, who was Professor of Chemistry at the Royal Institution in London. Dewar performed the most important researches yet done in the field of soap films. Lawrence was for many years Dewar's assistant at the Royal Institution. This book also presents a very helpful discussion of how the best solutions for various types of soap films and bubbles may be made The following points are interesting.

The only suitable acid for making soap for soap film production is oleic acid, which has, however, the disadvantages of being hard to purify and hard to keep pure. For long-lived films and bubbles all impurities must be rigorously excluded. Methods for purification of oleic acid to make it suitable for these special soaps are given in the appendix.‡ The presence of small amounts of palmitic and stearic acids (probably always to be found in present-day "Castile" soap) is very deleterious.

Since small amounts of impurities have such profound influences on the soap films, the behavior of such films may vary from day to day, although under apparently the same conditions.

In the making of the soap, excess of sodium hydroxide or potassium hydroxide is "fatal to film-forming capacity." The potassium soap has no advantages over the sodium soap. Far superior to either of these, Dewar found, were the oleates of ammonium and of

* Present address: Linde Air Products Co., Buffalo, New York.

† The writer is indebted to Professor E. S. Ault of the Case School of Applied Science for calling his attention to this use of soap films.

‡ For an improved method of purifying oleic acid see BROWN, J. B. AND G. Y. SHINOWARA, *J. Am. Chem. Soc.*, **59**, 6–8 (1937).

triethylamine. The latter was found to be the best for open-air work. The highest concentration of soap in any of Dewar's solutions was five per cent., but solutions with less of the soap worked equally well and sometimes better. In making ammonium or triethylamine oleates, exact neutralization of the oleic acid is not necessary, and the solutions can be made up by volume. The main thing is the purity of the acid and base—especially purified oleic acid kept in sealed tubes, and freshly distilled triethylamine.

All soap solutions must age at least a day before use.

Lawrence says that the function of the glycerine used in all the solutions is the stabilization of the films against local discontinuities arising from various causes. Like Boys, Lawrence recommends the addition of a trace of ammonia to a solution made of a sodium or potassium soap.

After the films or bubbles are prepared, the chief destructive forces are carbon dioxide, grease, and any kind of floating particles like those of dust.

Films as large as nineteen centimeters in diameter lasting up to three years, and bubbles up to forty centimeters in diameter lasting as long as one hundred days, were prepared in closed vessels. These closed vessels serve the purposes of excluding destructive agents like carbon dioxide and dust, of preventing drying out of the films and evaporation of volatile bases, and of protecting from mechanical shock, any of which would shorten the life of the films. It will be noted that films are under the same conditions, much longer lived than bubbles.

Some of the earlier experiments performed by Sir James Dewar are described in various articles (*5*). A more extended discussion (*6*) begins by ascribing the pioneer work on lasting soap films to Joseph Plateau, Professor of Physics at Ghent. Then experiments by Dewar are described. He obtained dust-free air for blowing soap bubbles by allowing liquid air to evaporate in a closed vessel. Various methods of insuring that the closed glass-walled boxes in which he blew his soap bubbles were dust-free are described, one of which was to displace the air in the box with air purified by passing it through soda-lime (to remove carbon dioxide) and then cotton-wool dampened with glycerine. Many long-lived soap bubbles were thus blown, lasting up to ninety-five days for a bubble twenty centimeters in diameter (using five per cent. potassium oleate in fifty per cent. glycerine solution). Flat films in bottles lasted much longer.

In an article in the *Proceedings of the Royal Institution* (*7*) Dewar describes his use of the new soap, triethylamine oleate, along with other soaps.

Trayer and March (*8*), in trying to find a solution that would give lasting soap films in the open air, found only triethylamine oleate satisfactory. They give the directions they used to make up their solutions, which yielded single films that often lasted throughout a working day. They explain the mathematical analogy between stress in beams and the behavior of a membrane under pressure. The usefulness of this analogy for research in machine and structural design depends on the fact that it gives an *experimental check* on the stress distribution in a beam, etc., when there are ways known of calculating it, and also that it "offers a means of determining the torsional rigidity and the stress of important irregular sections that have *not* yielded to mathematical treatment."

This article also contains a good bibliography on the use of the soap-film analogy in engineering research. Attention was first called to this analogy by Prandtl (*9*).

Johnston (*10*) substituted triethanolamine (which he spells triethynolamine) oleate for triethylamine oleate with entirely satisfactory results, claiming that some of his films lasted three or four days. The triethanolamine is less expensive than triethylamine. The former is a comparatively new commercial product (*11*).

The existence and structure of soap films is discussed by Lawrence in his book (*4*) and also in a more recent article (*12*). Lord Rayleigh first suggested (*13*) the most generally accepted hypothesis that a soap film has a sandwich structure and that the stability of the film depends on the presence of a surface layer at each face, between which is included a variable thickness of the liquid of the solution.

In the formation of a soap film it is necessary to have a solution in which the surface tension of water has been reduced to about one-third its value when pure, and *also* to have present molecules capable of forming oriented surface layers tough enough to overcome the disruptive force of the surface tension still remaining, for "soap films do not exist as a result of surface tension, but in spite of it" (*4*, p. ix).

Lawrence believes that soap films "are not colloidal in their nature, in the sense of having a gel structure between the two layers, or of the layers being colloidal" (*12*). This view is not shared by W. J. Green, however, who was also an assistant to Dewar at the Royal Institution. He writes (*14*), "After years of observation I find it difficult to accept that one oriented layer and one irregular reserve layer below this on either face, and nothing but chaos between, can explain the appearances presented by soap films, or maintain their tenacity." Green's general argument is that many kinds of solutions have special surface layers, but only soap solutions give *stable, mobile* films. "If their mobility and permanence is to be ascribed solely to surface layers, these must be of surprisingly unique cohesiveness." With these last words everyone can certainly agree. It seems to the writer that Green's own statement of the argument is a most convincing way of arguing for the Rayleigh theory, since a consideration of the structure of soap-forming molecules would seem to show that these long, slender, thread-like bodies would be precisely the kind of units capable of forming very strong, cohesive surface layers.

Green has recently reported (*15*) some more work on soap solutions done at the Royal Institution, in which he found that various other alcohols, such as ethylene glycol and ordinary ethyl alcohol, could be substituted

for glycerine in making good soap solutions. He used only about one-fourth the volume of ethanol that he used of glycerol for a given solution.

EXPERIMENTAL

This field of experimentation is the kind in which an infinite series of experiments could be performed, each with some change in one of the many variables. Among these variables are (1) the purity of the oleic acid; (2) the purity of the base used; (3) the manufacture and preservation of the soap; (4) the composition, preparation, and preservation of the soap solution; (5) the apparatus and conditions for blowing the bubbles or making the films. The effect of traces of impurities, tiny quantities of dust, the relative humidity of the atmosphere and its carbon dioxide content, etc., is so great that really quantitative experiments can be performed only in closed vessels and with extraordinary precautions to exclude impurities. In fact, the work of Dewar and others has shown that, given pure materials, clean, CO_2-free air, and protection from mechanical shock, soap bubbles, and films may be made almost immortal compared to their brethren blown without precautions in the open air with ordinary soap solution. The chief purpose of the present experiments was to find directions for making a solution which could be prepared from materials readily available and in a minimum of time, that would yield bubbles lasting from one to five minutes in the open air without special protection. Such a lifetime is ample for ordinary chemical lecture experiments involving soap bubbles.

The first solution used was that made up according to Benedict (*1*, p. 52) using Baker and Adamson's Castile soap in powdered form. When this solution was used, prepared without any special precautions, bubbles blown with a hydrogen-oxygen mixture would only occasionally leave the pipe unbroken. The problem of having the bubbles unfailingly leave the pipe unruptured was first attacked by putting various substances (like vaseline) on the rim of the bowl of the pipe. None of the substances tried seemed to help. Next, at the suggestion of Professor F. E. Bartell of the University of Michigan, a little tannin (Baker and Adamson's C.P.) was mixed with the soap solution just before use. It immediately strengthened the soap bubbles so that they each came off the pipe whole and unbroken. This addition of tannin has been used by the writer and others on various separate occasions, and has always resulted in satisfactory bubbles.

Before starting a systematic series of experiments on the use of tannin, various kinds of pipes were tried. An ordinary ten-cent straight-stemmed tobacco pipe, from the five-and-ten-cent store, with a bowl made of a hard, smooth composition material, was found to be as satisfactory as any. The technic used to blow the bubbles was to pour a little of the solution to be tested into a watch glass, to dip the pipe bowl into it (when it was ascertained that the interior of the bowl was thoroughly wet with the solution); to raise the pipe without turning the bowl right-side up and immediately blow a slow steady stream of compressed air into the pipe.* The drop of solution hanging from the bottom was not shaken off, as its removal greatly decreased either the longevity of the small bubbles or the size to which the large ones could be blown. During the inflation, and also while holding the pipe to measure the life-time of the bubble, the pipe was held firmly against a buret clamp fastened on a ring stand. The time of blowing the bubbles and the life-time of the bubbles were measured with a stop-watch; and the diameter of the bubbles was estimated by sighting past them to a ruler fastened back of them.

Surface tensions were measured with a du Noüy tensiometer, the usual precautions being observed. The readings on the dial were corrected from a calibration curve constructed by measuring, with the tensiometer, surface tensions of pure liquids for which the surface tensions are well known (*16*).

Two types of measurement were used on the bubbles blown from each solution.

(1) *The bursting diameter.*—Compressed air was blown into the bubble in a slow, steady stream, and the diameter of the bubble at the instant of bursting was estimated. A stop-watch was used to measure the time elapsed from the instant of bursting. In connection with this type of experiment, however, it should be remarked that beyond a certain diameter, the size to which soap bubbles can be blown depends, not on the solution, but on having some device which will keep supplying the solution through the pipe from which the bubble is being blown. For blowing very large bubbles special pipes must be used.

(2) *The lifetime of a bubble approximately ten centimeters in diameter.*—The stop-watch was not started till the compressed air was shut off.

Results.—The measurements made on soap bubbles from the various solutions, and the surface tensions of those solutions, are given in Table 1.

Every figure in the following table, with the exception of the surface tension measurements, is the average of ten determinations.

It will be seen from the table that the best results were obtained by adding 25 to 100 milligrams of tannin to 25 cc. of the glycerine-soap solution. It also appears that the addition of tannin alone to soap solution, without using glycerine, is not of much value unless very large amounts of tannin are added; but even then the lifetimes of the bubbles are small compared to those of the best tannin-glycerine-soap bubbles.

Another interesting fact is that while the addition of a small amount of tannin helped greatly in toughening these bubbles, the addition of a large amount not only did not help, but undid the beneficial effect of the glycerine. There is thus an optimum amount of tannin to be added for the production of the best results.

The change in surface tension from that of pure

* The gas with which a bubble is to be blown should always be turned off before the pipe is dipped into the soap solution, in order that an initial film can form over the mouth of the bowl.

water to that of the solutions used in this experiment is enormous compared to the differences in surface tensions of the solutions themselves. Moreover, the surface tension of the very best solution (Number 5 in Table 1) is almost exactly the same as that of soap solution alone (Number 1); and the excess of tannin, although decreasing the surface tension further, weakened bubbles blown from it. It seems out of the question, therefore, that the strengthening effect of the tannin could be ascribed to its surface tension depressing effect.

TABLE 1

	Average lifetime of 10 cm. bubbles in sec.	*Bursting diameter in cm.*	*Time of blowing in sec.*	*Surface tension of the solution in dynes per cm.*
1. Clear, saturated soap solution...	6	13	11	25.8
2. Glycerine added, no tannin.....	34	17	15	27.5
3. 10 mg. tannin per 25 cc. of solution 2.....	28	20	18	26.5
4. 25 mg. tannin (solution 2).....	65	20	22	26.0
5. 50 mg. tannin (solution 2).....	66	21	27	25.6
6. 100 mg. tannin (solution 2).....	61	20	25	25.0
7. 500 mg. tannin (solution 2).....	7	12	10	24.8
8. 10 mg. tannin per 25 cc. of solution 1.....	6	13	10	25.6
9. 50 mg. tannin (solution 1).....	8	—	—	25.1
10. 500 mg. tannin (solution 1).....	17	17	18	24.6

It is possible that the function of the tannic acid is nothing more than to neutralize traces of excess alkali in the soap solution, but more likely the tannin molecules orient themselves in the surface structure of the soap films, along with the glycerine molecules; for the tannin molecules themselves have hydroxyl groups, some of which are probably similar to those of alcohols. (*Cf.* Green (*15*).)

A few bubbles were blown with nitrogen instead of air. These could not be made large enough so that the buoyancy of the nitrogen actually overcame the weight of the soap film, but such bubbles, after being separated from the pipe, fell very slowly through the air, beautifully iridescent due to the interference of the light reflected from the front and back surfaces of the soap film. Of course the introduction of a little hydrogen or illuminating gas makes the bubbles float or rise. The beauty of large soap bubbles is very striking, and many entertaining experiments can be performed with them. (*Cf.* Boys (*3*).)

Other Experiments with Castile Soap.—In a series of experiments to find out approximately what concentration of soap yields the best solution, various concentrations of soap in water were prepared, with glycerine added later. The final solutions were two per cent., three per cent., and five per cent. (by weight) Castile soap. Life-times of 10–11 cm. bubbles blown from these solutions, each value being the average of ten trials, were respectively one hundred twenty, seventy-one, and ten seconds. The two per cent. solution, therefore, proved to be by far the best of these.

Addition of a little tannin increased the average lifetime of bubbles obtained from the two per cent. soap-glycerine solution by about forty seconds. The longest lived bubble ever blown from such a solution by the writer lasted one hundred ninety-two seconds. For longer-lived open-air bubbles one must have recourse either to intensive purification of the soap, or to other soaps.

The writer could get no striking increase in lifetime by adding a trace of ammonia to the solutions, nor by the use of small quantities of saponin or rosin instead of tannin.

Experiments in which ethyl alcohol was used instead of glycerine in the ratio recommended by Green (*15*), showed that for open-air work alcohol cannot be substituted for glycerine, since the alcohol quickly evaporates. Green's experiments were probably performed inside protective boxes or bottles like those used by Dewar. Ammonium oleate cannot be used for open-air work for a similar reason. The ammonia is too volatile a base to be used except in a closed vessel.

To test the lifetimes of flat soap films in the open air, squares of thin galvanized sheet-iron (3 × 3 in.) had circular holes (34 mm. in diameter) cut in them. The edges of the holes were beveled and then smoothed with emery paper so that there were no rough spots. After being cleaned, these pieces of metal were thoroughly wet on both sides with the soap solution to be tested and a film then stretched across the hole by rubbing a horn spatula (wet with the solution) across it.

These small flat films were much longer lived than 10 cm. bubbles under the same conditions. They therefore exaggerated the differences between solutions. Thus a dilute solution of Castile soap in water *without* glycerine gave films averaging thirty-four seconds in lifetime; the same solution plus a little ethyl alcohol averaged eighty-two seconds; but with glycerine, the lifetimes increased to an average of sixteen *minutes*. The non-volatile, hygroscopic glycerine keeps the film moist and pliable. The longest lived film obtained in these experiments lasted twenty-one minutes, almost seven times the lifetime of the best bubble blown from the same solution, plus a little tannin.

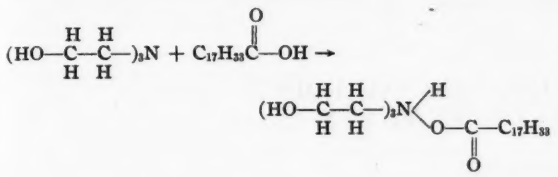
Triethanolamine Oleate.—This is easy to make and the solutions obtained from it are an enormous improvement over ordinary alkali soap solutions for open-air work with bubbles and films.

A sample of commercial triethanolamine was obtained through the courtesy of Carbide and Carbon Chemicals Corporation (*11*), and the oleate made from it in accordance with the directions in the pamphlet entitled "Emulsions" also furnished by this company. Since the triethanolamine is slightly contaminated with mono- and diethanolamines, and since the purity of oleic acid is always questionable, it is safest to titrate the amine in water against hydrochloric acid with methyl orange, and the oleic acid in alcohol against sodium hydroxide with phenolphthalein. The writer used Merck C.P. oleic acid (light yellow color), and found the actual ratio of acid to amine (by weight) for

neutralization to be 1.98, whereas the theoretical ratio given by the molecular weights (in this case the same as the combining weights) is

$$\frac{282.3}{149.1} = 1.893$$

Since exact neutralization is not necessary in making the soap, a slight excess of the base even being beneficial for soap film work, it suffices to weigh out any convenient amount of triethanolamine and to add slightly less than twice its weight of C.P. oleic acid. The reaction is simple addition:



No water is formed. The two reactants are merely thoroughly stirred together. The heat of neutralization warms the mass somewhat. At first the color of the soap is light and creamy, but on aging a day or so it turns red. It does not harden, but remains about the consistency of lard.

Experiments to find out the optimum concentration of soap in solutions made from this oleate were performed, and showed, as in the case of the Castile soap, that a solution of approximately two per cent. was the best of those tried.

On standing twenty-four hours, a solution of triethanolamine in water separates into two layers, an upper, light-brown, very viscous solution, and a lower, light-gray solution with viscosity about the same as that of water. The colors indicated are those seen by reflected light; no difference between the layers was visible by transmitted light. Titration of samples from each of the layers showed that the upper (viscous) layer was richer in acid, and the lower contained an excess of the base. These results are presumably due to hydrolysis of the oleate, which is a salt of a weak acid and a weak base. Average results for some of the solutions tried out may be summarized as in Table 2.

It must be emphasized that these results, and the others presented in this paper, have comparative value only. Very small changes in conditions make huge changes in the life-times of the films and bubbles in the open air.

The longest lived bubble obtained was from solution 6 (Table 2). It lasted seventeen and one-half minutes in the open air before bursting. The longest lived film obtained (from the same solution) lasted three and a quarter hours.

SUMMARY AND CONCLUSIONS

The literature has been reviewed and various experiments reported, with the purpose of finding simple sets of directions for making up soap solutions that will yield lasting films and bubbles from readily available chemicals requiring no special purification.

Triethanolamine oleate solutions were found to be greatly superior for open-air work to Castile soap solutions, but the latter give bubbles that are satisfactory for the average chemical lecture experiment.

If there is any danger of acid-spray, grease, or dust entrainment in the gas used to blow the bubbles, it should first be passed through a glass tube containing cotton moistened with glycerine.

Directions for making up the best solutions the writer used are as follows.

Castile Soap.—The powdered soap (30 g.) is placed in a one-liter glass-stoppered bottle and distilled water added to fill the bottle. The bottle is shaken at intervals till solution is complete, then allowed to stand twenty-four hours or more. The solution does not become entirely clear, but sufficiently so for use. The clear part is siphoned off and three-tenths of its volume of glycerine added and thoroughly mixed with it. The solution should age at least twenty-four hours before use. The bottle in which the solution is stored should at all times be kept well-stoppered and in a dark place.

When it is desired to use the solution, a small volume (25 cc.) is poured out and stirred with a little tannin (25 to 100 mg.).

Triethanolamine Oleate.—Any convenient weight of triethanolamine is thoroughly stirred with a little less than twice its weight of oleic acid in a flask (no heating necessary). The flask is stoppered and set aside for twenty-four hours.

A thirty-gram portion of the resulting soap is mixed with about a liter of distilled water, in which it slowly dissolves. Solution is hastened by occasional shaking. Finally, it is allowed to settle for twenty-four hours. (It becomes translucent but never clear.) The lower, light-gray layer is siphoned off and mixed well with three-tenths of its volume of glycerine. The solution is stored in the dark, and the bottle in which it is kept is well-stoppered to protect it from the air. After aging for twenty-four hours it is ready for use.

TABLE 2
TRIETHANOLAMINE SOLUTIONS

	Average lifetime of a 34-mm. diam. film, minutes	*Average lifetime of a 10-cm. diam. bubble, minutes*
1. 3% (by weight) soap in water alone, upper layer..	3	—
2. 3% (by weight) soap in water alone, lower layer..	7	—
3. Upper layer plus 0.06 of its volume ethyl alcohol.	2	—
4. Lower layer plus 0.06 of its volume ethyl alcohol.	5.5	—
5. Upper layer plus 0.3 of its volume glycerine.....	40	—
6. Lower layer plus 0.3 of its volume glycerine.....	145	10
7. Layers not separated; instead, solution (with glycerine) mixed just before use.....	100	2.5

LITERATURE CITED

(1) BENEDICT, F. G., "Chemical lecture experiments," The Macmillan Co., New York City, **1925.**
(2) HODGMAN, C. D., "Handbook of chemistry and physics," 21st ed., Chemical Rubber Publishing Co., Cleveland, Ohio, **1936.**
(3) BOYS, C. V., "Soap bubbles, their colors and the forces which mold them," The Macmillan Co., New York City, **1924.**
(4) LAWRENCE, A. S. C., "Soap films," G. Bell and Sons, Ltd., London, **1929.**
(5) ANON., *Engineering*, **101,** 87 (1916); and *ibid.*, **105,** 98 (1918). (Reports on talks by J. Dewar.)
(6) DEWAR, JAMES, *J. Franklin Inst.*, **188,** 713–49 (1919).
(7) DEWAR, JAMES, *Proc. Roy. Inst. Gt. Brit.*, **24,** 197–259 (1925).
(8) TRAYER, G. W. AND H. W. MARCH, "The torsion of members having sections common in aircraft construction," Report No. 334, National Advisory Committee for Aeronautics.
(9) PRANDTL, L., *Physik. Z.*, **4,** 758 (1903).
(10) JOHNSTON, BRUCE, *Civil Eng.*, **5,** 698–701 (1935).
(11) WILSON, A. L., "Triethanolamine emulsions," *Ind. Eng. Chem.*, **22,** 143–6 (1930).
(12) LAWRENCE, A. S. C., *J. Phys. Chem.*, **34,** 263–72 (1930).
(13) RAYLEIGH, J. W. S., *Proc. Roy. Soc.*, (*London*), **47,** 281 (1890).
(14) GREEN, W. J., *Nature*, **126,** 276–7 (1930).
(15) GREEN, W. J., *ibid.*, **131,** 873 (1933).
(16) MACY, RUDOLPH, J. CHEM. EDUC., **12,** 573–6 (1935).

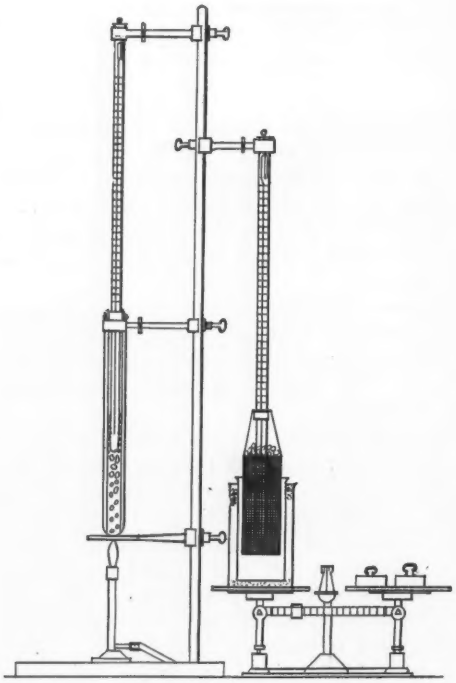
APPARATUS FOR DETERMINING BOILING POINTS AND FREEZING POINTS OF SOLVENTS

E. E. CHANDLER

Occidental College, Los Angeles, California

THE drawing shows a simple setup for determining molecular weights by elevation of the boiling point and depression of the freezing point of the solvent.

The main error in boiling-point methods is due to overheating and a consequent unstable mercury column. This is avoided in the McCoy apparatus by boiling the solution with the vapor of the pure solvent, which also acts as a jacket to prevent the solution from losing heat to the atmosphere. Over-heating is minimized in the Cottrell percolator method by having bubbles in the solvent or solution burst over the bulb of the thermometer.



In this apparatus the solution is in a large test-tube about a foot long. Inside this is a glass tube open at both ends, and inside this tube is the thermometer, which should reach to the level of the liquid. The test-tube rests on an asbestos wire gauze from which a small amount of asbestos has been removed under the bottom of the test-tube. With a small flame, boiling takes place only in the inner tube. The bubbles of steam rising several inches from the flame to the bulb lose their excess heat, as in the Cottrell method. The annular space between the tubes jackets the thermometer and helps to hold the mercury steady. When the solute is introduced the inner tube may be lifted a few times to insure mixing. This simple apparatus gives quite as good results as the more elaborate apparatus mentioned. No condenser is necessary as the long test-tube partly closed with cotton provides good condensation. In any event the solution may be weighed after the determination, the weight of the solute deducted and the calculation made.

The novelty in the freezing-point apparatus consists in a wire basket containing ice, hung to the thermometer by the rubber band surrounding it. Equilibrium is obtained by moving the basket and thermometer up and down in the nested beakers or by so moving the beakers by means of the balance. After the freezing point of the solution has been determined, the basket and thermometer are suspended above the beakers and the weight of their contents determined.

The CHEMIST *at* WORK

ROY I. GRADY AND JOHN W. CHITTUM

The College of Wooster, Wooster, Ohio

*Introduction**

THE contributions of chemistry to the advancement of civilization have received considerable attention. For example, those publications supported by the Chemical Foundation which portray the accomplishments of chemistry have done much to make America chemistry-conscious.

Other publications equally as important have been and are being prepared which show how chemistry is serving man, and how it may do so more effectively in the future. Again the work of the Chemical Foundation with the Farm Chemurgic Council is a case in point.

In spite of the increasing amount of material on what chemistry has done and may do in the future, there seems to be a dearth of information on what the chemist himself does and how he does it. A few outstanding biographies, such as "The Life of Pasteur" constitute the exceptions.

One of the reasons why such biographies have been so well received is that they give specific illustrations of how the individuals solved certain problems which confronted them. Most persons seem to be interested in the individual, his life, what he does, and how he does it.

Such information regarding what the chemist does should be of extreme value and interest to many persons. For example, it is apparent that the average student has considerable difficulty in selecting a suitable vocation. The information available regarding what is involved in a given profession is quite meager. A student, for instance, may like chemistry as a study, but he does not know whether he would like it as a life work. The ordinary vocational talk is entirely too general to be of much assistance. The writers of this paper believed that they could help the student in this matter by compiling a description of the chemist's work and problems in the various fields of chemistry so that anyone interested could obtain a fair cross-sectional picture of the profession.

In order to accomplish this purpose they asked a number of persons engaged in different fields of chemistry to write accounts of their work. These persons were asked to describe the general nature of the activities in which they were engaged and to give several examples showing how specific duties are performed. The persons who were asked to contribute were selected so that they would represent as many different degrees of attainment as possible. Some of them have spent a life time in the profession; others have been graduated from college but three or four years.

The contributors discussed duties and problems in many different fields. Thus it is believed that these articles will give the reader a representative picture of the work of the chemist. This should be of interest and value to the layman, the student, and the chemist.

As these articles are published, the editors wish to acknowledge their obligation to the different contributors. It is obvious that without their generous cooperation, this undertaking would have been impossible.

* A revision of a paper presented before the Division of Chemical Education at the ninety-third meeting of the A. C. S., Chapel Hill, North Carolina, April 13, 1937.

I. THE PLANT CHEMIST

J. ALFRED HALL

At the time this article was written Dr. Hall was Biochemist with the Forest Products Laboratory of the U. S. Forest Service at Madison, Wisconsin. In 1937 he became Associate Director of the California Range and Experiment Station. He attended Earlham College and Indiana University for a time and received the B.S., M.S., and Ph.D. degrees from the University of Wisconsin. He is a member of the Phi Beta Kappa and Sigma Xi societies. Dr. Hall is the author of several publications on plant chemistry.

+ + + + + +

It was about eight years after graduation before I discovered what kind of a chemist I was, and that happened only when I entered the Federal Civil

Service and achieved a title, *viz.*, Biochemist. Now that is a sufficiently broad classification to cover almost anybody operating in the field of vital products. However, in my own case, the work has been confined to plant products. Thus, the classification might very well be plant biochemist, but it would still be erroneous in view of the fact that one works mostly with materials separated from the plant and, therefore, no longer in the sphere of vital activities. Suppose we say then, just to be on some sort of solid ground, that I am a plant chemist, primarily interested in how plants manufacture the myriad of substances which they produce.

We must admit that this is a large order, especially since the groundwork of the problem is still a very rickety piece of construction. That is, we as yet know comparatively little about the actual substances, produced by the plant as end-products of their growth and next to nothing about the substances that are intermediate between the sugar of photosyntheses and the end-products. The specific problem that I am busied with is the elucidation of the chemical mechanism by which the pine trees of the southeastern states produce the oleoresin from which are obtained the turpentine and rosin of commerce.

Here is the problem, briefly. The tree is wounded into the sapwood, and from the wound exudes the sticky water-insoluble oleoresin. Repeated wounding causes repeated exudation, and the process can go on almost indefinitely. Under proper conditions, a tree can be turpentined for one hundred years. In the first place, the exudation of resin from a water-filled tissue is peculiar enough, although we can see how the resin exudes from specialized passages. However, we want to know how the resin gets there, and, above all, where in the tree it is formed, and by what mechanism.

There appeared to be two avenues of approach, as is usually the case in any research problem—the library and the laboratory; the library first, of course. In pine oleoresin, we are dealing with a material which contains terpenes and resin acids, both of which are produced by many plants other than the pine tree. In fact, terpenes are so widely spread in the plant kingdom that one considers them almost universal. Both groups, as well as many other compounds, are made up of a simple unit, put together in different ways to form different compounds. In fact, the general occurrence of what we choose to call isoprene polymers leads us to think that their universality is the result of a general law of plant chemistry. The only trouble is we have never found any isoprene in plants, nor do we know from what it arises.

The first fruit of library research was a clear picture of the close relationship of the whole terpene and resin acid family, and the development of a hypothesis in which these substances were derived from water-soluble precursors which in turn could be theoretically derived from sugars such as we know are formed by photosynthesis. All this was purely hypothetical and based on a thorough survey of all the recorded occurrences of these substances. Also, I was drawing somewhat on past experience in postulating water-soluble combinations for the translocation of oleoresinous substances in the plant.

With this hypothesis developed, nothing remained but to attack the tissues of the pine tree and the oleoresin itself and see what could be found. Clearly, we were compelled to deal with the material separated from the tree, because in the present state of the problem, we had no knowledge with which to begin any other study. I might as well admit now that we are a long way from the solution, but there are rays of hope. In the oleoresin I found a very small quantity of a water-soluble substance with peculiar properties. It was soluble in either ether or water. It was evidently carbohydrate in nature, and, upon hydrolysis of the very small quantity available, I found I had a glucoside decomposing into a sugar, a volatile oil, and a resin which gave at least the color reactions of a resin acid. Now, of course, that was what I had hoped for, but the amount here was so small that it would have cost a fortune to get enough with which to work. So I began the examination of the inner bark of the tree. This tissue contains, along with a great amount of other materials, a small amount of apparently the same glucoside, although I am not at all ready to state that they are the same. Its isolation, and the necessity of assuring myself that I am not overlooking something else of importance compels a pretty complete analysis of the tissue. This work is yielding a considerable amount of information which will all be fitted into the picture when it is done, we hope. In the meantime, I have started the same sort of survey on the growing tips of the tree, and have great hopes of finding this glucoside in sufficient concentration to enable a good characterization.

One might ask, "What of it? Of what possible benefit to humanity will it be if you do find out how a pine tree forms oleoresin?" Well, the problem is a bit larger than that in its application, for it is, after all, a part of the big problem of synthesis in plant life, and thus a part of man's attempt to free himself from the trammels of his natural environment. Immediately, of course, the objective is to get better control of our vast pine forests and operate them more intelligently. To do that, we need to know all we can about what goes on in them. I spent some years in California helping develop a by-products industry from oranges and lemons. There, our limiting factor was always our lack of knowledge of the actual make-up of the fruits with which we were working. In short, we cannot know enough about our materials to get efficient management of their production.

A good illustration of this point can be derived from our work on oranges in California. Specifically, it was thought that the undesirable odors developed in preserved orange juice arose from chemical changes taking place in the volatile odorous constituents of the fresh juice. It followed that we needed to know what these constituents were. I worked up about 25,000 gallons of juice and obtained about one pint of volatile

oil. After sorting out its constituents to the best of my ability, we concluded that they were not responsible, but we knew a lot more about the odor of fresh orange juice than we did before. Then there was the problem of the bitter taste that develops in certain orange juices on standing. That I was able to locate as coming from the tissue covering the pulp sections, and actually isolated a little of the bitter principle, probably impure. However, we found out enough about it to give us some control over the production of juice from these oranges. Incidentally, it was this work on orange glucosides that started the thought on the mechanism by which water-insoluble bodies are moved through the sap of the plant, and led to the development of the hypothesis on which my present work is based.

The chemist who chooses to work with plant substances along the lines indicated above will probably never run out of problems. Indeed, in spite of the thousands of substances that have been isolated from plants, the surface has hardly been scratched, and hundreds of interesting plants still await their first investigation. Hundreds of others have been examined in cursory fashion, with only those substances being obtained that were easy of access. A mere handful of plants have been subjected to anything like a complete examination. Such research, however, requires money and, except in cases of plants of known commercial importance, adequate financial support has been lacking. The young chemist, looking for a field of large financial profit, might well search elsewhere, for his rewards in plant chemistry will probably not be pecuniary. However, in the field of pharmacy, and in those technological processes directly utilizing vegetable products, there are ample opportunities for the research plant chemist. It is not often that such fields develop data of direct interest in the field of plant synthesis, but it must be remembered that all careful work in the characterization of plant substances must some day be of value in elaborating a complete theory of photosynthesis. Thus, even the routine worker in the drabbest field can contribute to the larger objective, and earn a living while satisfying his desires for research.

Fortunately, the chemist well trained for careful phytochemical labors is also trained for general organic work. Thus, as for making a living, he is doubly equipped, with the advantage that, if opportunity offers, he may combine a living with labor in a field where unrivalled opportunities for productive investigation continually challenge the patient and imaginative worker.

[When Dr. Hall was asked what training and personal qualifications a plant chemist should have, he replied with the following description of an ideal phytochemist.]

Let us assume that we have a healthy, industrious man, with a good brain and a healthy imagination. He must be as capable with his hands as with his head for he will need to be a bit of a carpenter, plumber, steamfitter, electrician, and laboratory man, and not afraid to get a little dirty in working. Now, if he has a highly developed bump of curiosity directed toward things of nature, and has or can develop a true sense of scientific accuracy, he is worth risking with a course leading to a Ph.D. in chemistry.

Let his training include:

(1) The usual undergraduate courses in chemistry, physics, and botany.
(2) All the organic he can get with emphasis on characterization and natural substances.
(3) Physical chemistry. The theoretical background is desirable but not indispensable. Knowledge of the "working tools" is necessary.
(4) A lot of plant physiology. The combination of thorough chemical training and plant physiology in the right man makes an irresistible combination.
(5) German and French at least, and the more languages the better.

I assume he will have a mastery of clear, concise English, for without it he is hopeless. Let him learn some economics and any others of the social sciences, for he must have a bit of altruistic social philosophy to be happy in his work. In short, in addition to the necessary technical courses listed above, educate him, if possible, in as broad a fashion as he can take, for he will need vision including fields far beyond the confines of the laboratory.

II. CHEMISTRY IN THE INSURANCE BUSINESS

WARREN A. HOUGH

The second contribution to "The Chemist at Work" was prepared by Mr. Warren A. Hough of the Travelers Insurance Company of Hartford, Connecticut. Mr. Hough graduated from Trinity College and spent five years as production manager for a manufacturing pharmacist before accepting his present position. He presents the work of a chemical engineer in the insurance business.

✦ ✦ ✦ ✦ ✦ ✦

This insurance company, which writes life, accident, automobile, casualty, fire, boiler, machinery, and

several other kinds of policies, has been able to make good use of a service which approximates that of a commercial analytical and testing laboratory. This laboratory at present serves principally the boiler, machinery, workmen's compensation, public liability, and fire insurance departments, but it is constantly enlarging its scope to serve other departments as well. In the beginning it should be stated that the work of this laboratory does not include the analysis of medical specimens in conjunction with the examination of life insurance applicants. This work is taken care of in a separate department and by individual medical examiners in the various branch offices.

APPARATUS FOR TESTING THE EXPLOSABILITY OF DUSTS

A cloud of corn starch dust is here shown exploding. The hinged spring cover of the explosion chamber can be seen behind the cloud of smoke and flame.

As a general principle, any material which will burn in air, will, if present as a cloud of fine dust and in sufficient concentration, form an explosive mixture with air.

Among the materials which have been known to give dust explosions are: wood flour, corn starch, aluminum dust or powder, grain dust, and coal dust.

Materials which have non-explosive dusts as a general principle are: most minerals and rocks, and metals (other than aluminum and magnesium).

When the company insures a boiler against explosion or failure under pressure, it is interested in knowing all of the circumstances connected with the operation of that boiler. The proper conditioning of boiler feed water is, therefore, of great interest, and this laboratory will, for any boiler policy holder, analyze the feed water, test varies types of treatments for properly conditioning it, and instruct the policy holder in the use of the most desirable and most economical type. In the case of a boiler failure, metallurgical examination is made of various parts of the boiler and an attempt made to determine the cause with a view to the prevention of future failures. Analysis is made of scales and sludges found in boilers, with a view to devising means for their elimination.

The foregoing is a rather specialized subject, and around it has grown up a vast collection of literature and widely diversified theories of water conditioning. The analysis of water, boiler scales, and the metallurgical examination of boiler metal is in itself fairly simple and can be handled by a person with little or no professional chemical training after a short period of instruction. To guide an organization through the maze of theories and to keep abreast of new developments in this subject, however, is a problem worthy of the efforts of a scientist of the highest qualifications. Since it is to the interest of an insurance company to promote the use of boiler treatments which will prevent losses through failures, rather than simply to sell a preparation, all types must be examined, their merits or shortcomings discovered, and the better types recommended for use in a scientific manner.

The handling of boiler water conditioning problems is, therefore, a combination of routine analysis of various simple materials with a very complicated and elusive research problem. An understanding of the design and construction of boilers and their appurtenances, such as treating tanks, pumps, economizers, and the like, is necessary, and if the individual is not familiar with the subject as the result of college training, a knowledge of it must be acquired by supplementary reading.

A considerably wider field of analytical chemistry is brought into use by the problems created through the writing of workmen's compensation and of public liability insurance. The insurance company, of course, seeks to avoid losses due to persons being injured by the activities of others. Not all of these hazards are of a chemical nature or subject to chemical control, but a large percentage of all activities, particularly manufacturing, involves one or more processes which are of a chemical nature and may cause injury unless understood and guarded against. Any process giving rise to dust or fumes must be investigated as being a possible hazard to the health of the workers, or as being the source of a possible explosion disaster. Most mineral dusts are regarded as harmful when breathed, but some are much more so than others. Nearly all organic dusts, as well as some metallic dusts, are explosive when suspended in the air. Fumes of many organic liquids are both poisonous and explosive. It is, therefore, necessary that the materials causing dusts or fumes be analyzed for purposes of identification, or to evaluate their concentrations in the air for the purpose of measuring the hazard involved. There is almost no material in use which may not sooner or later require analysis by the insurance chemist. It might be useful at this point to describe a typical day in an insurance

company's chemical laboratory. Four people work in the laboratory. One of them analyzes boiler feed waters almost continuously, while another calculates the results of the analyses into treatments for conditioning the water, tries out the treatments in various test apparatus and attends to the correspondence connected with this work. A third person, who is in charge of the laboratory, attends to most of the inquiries from underwriters and claim adjusters, makes occasional field trips for the inspection of risks, and in his spare time does research work on problems connected with the functions of the laboratory. The fourth person, the writer, attends to nearly all the analytical work except that of boiler feed waters, and it is his day which is here described.

Work unfinished on the previous day is attended to first. In this instance a determination of mercury in samples of felting fur is being made. In the hat industry the rabbit fur is carroted by treating it with mercuric nitrate. If the excess of this compound is not removed by washing, subsequent handling of the material in the forming operations is likely to cause mercury poisoning. The determination in progress is, therefore, a check on the thoroughness of the removal of excess mercuric nitrate. The method used is that of a well-known investigator in the field of industrial hygiene and consists of the destruction of the large mass of organic matter (fur) by means of concentrated nitric acid, the precipitation of the mercury as sulfide in weakly acid solution and the purification and weighing of this substance.

The next job at hand is a very prosaic one—the testing of the dielectric strength of some samples of transformer oils. This is done in a machine made for the purpose, and no skill is involved in reading the breakdown voltage as recorded on the dial.

At this point an inquiry comes by telephone from an underwriter who wishes to know how much a bushel of soda ash weighs. It seems that stevedores are carrying this material out of the hold of a ship in bushel baskets and the underwriter is afraid of strains resulting from carrying too heavy loads. The answer to this question would hardly be found in the "Chemical Handbook," so a bottle of soda ash is taken from the laboratory shelves, its contents weighed, and its volume measured by filling the bottle with water. The necessary calculation is then made.

The next job at hand is one which requires more technic than those heretofore described. It is the determination and calculation of the quartz content of a sample of rock dust. Chemical methods are inadequate for this determination, and a petrographic study of the dust is made under the microscope. After optical examination and measurements have revealed that the material is granite dust, a quantitative estimation of the quartz is made by areal analysis. The image of a ruled screen is projected into the field of the microscope and the particles of the sample are viewed as apparently lying on this ruled area. The number of squares covered by all other particles is counted, and then the number of squares covered by quartz particles is counted. A simple calculation now yields the percentage of quartz.

One now finds that a pharmaceutical manufacturer has applied for products liability insurance on tablets containing acetanilide and phenacetin. A sample has been submitted and a determination of these two ingredients is needed. A search of the usual reference books does not reveal any method of determining those two materials in the presence of one another, so a search is made in *Chemical Abstracts*. Finally a reference is found to such a method in a publication of the United States Department of Agriculture; the publication is obtained from a library and the analysis made in accordance with the directions there found.

Several samples of paint are now submitted for examination. A flash point determination is made on each of those in the closed cup flash tester; then some of the solvent is distilled off, and a test for benzol is made. A qualitative test for lead is now made by placing a drop of the paint on the corner of a microscopic slide, igniting it in an alcohol flame, extracting the pigment with a drop of dilute nitric acid and applying a drop of potassium iodide solution. If lead is present, characteristic crystals of lead iodide are formed and these are easily distinguished under the microscope. This method of Chamot and Mason may be carried out on a paint sample in five minutes or less.

A field inspector now brings to the laboratory a set of air samples taken in the vicinity of a chromium plating tank in order that the concentration of chromic acid vapors to which the workers are exposed may be determined.

A sample of the dust of a phenolic resin is tested to see if it is explosive. An apparatus for this purpose consists of a chamber in which a portion of the dust is beaten into a cloud by a revolving paddle, with a spark plug and coil to supply the source of ignition. If the dust is explosive, the fact is made clearly evident by the violent lifting of the spring hinged lid of the explosion chamber.

The foregoing perhaps describes a longer day's work than could ordinarily be accomplished, but it is a fair example of the great variety of work encountered. Tomorrow the schedule may call for the complete quantitative analysis of a boiler scale and a commercial boiler compound, the determination of the ammonia content of some refrigerator brines for the purpose of detecting possible leaks of ammonia into the brine tanks, the examination of a line of cosmetics submitted by a manufacturer who wished products liability insurance and the survey of the explosive vapor content of the air in an artificial leather plant.

It is, of course, impossible that the chemist should have at his fingertips a method of analysis for every variety of material which may be handed to him, but he must have a broad enough training and experience to be able to get at the needed information on short notice.

There are probably few jobs open to the chemist as interesting in variety of work encountered as those in

the insurance companies. The field of this work will of course expand more and more as the influence of chemistry and chemical processes makes itself felt in a greater number of industries every year.

[Mr. Hough indicates the training and personal qualifications desirable for such work as follows.]

A chemist employed by an insurance company to do work similar to that described in the foregoing paper should have the broadest possible chemical training. He should have specialized in chemistry or chemical engineering in college, with special emphasis on all types of analysis and on industrial chemistry. He should be a constant reader of the technical literature and make himself familiar with reference sources in many subjects.

As to personal characteristics, he should be resourceful, possess great adaptability, and be able to work with considerable speed. The type of scientist who painstakingly exhausts all the details of a specialized subject would hardly be suited to such work, and would probably be shocked at the occasional lack of exactness which is sometimes permissible. The type of chemist who can "do first things first," balance considerations nicely, and make up his mind as to how much accuracy and time each job demands will find insurance work very interesting and will be successful in it.

III. THE FIELD OF NUTRITION

WM. E. KRAUSS

The work of the chemist in The Field of Nutrition is presented by William E. Krauss, Associate in the Department of Dairy Industry of the Ohio Agricultural Experiment Station.

Dr. Krauss has been with the Experiment Station since 1926 and during that time he has carried on important researches in this field. He is a member of the Society of Biological Chemistry, the Dairy Science Association, and The American Institute of Nutrition. The results of his investigations have been published in the journals of these societies and in the Journal of the American Medical Association.

He received the degrees of Bachelor of Science and of Doctor of Philosophy from Cornell University and is a member of Sigma Xi and Phi Kappa Phi.

✦ ✦ ✦ ✦ ✦ ✦

Chemical Abstracts, the leading abstracting journal of chemical literature, divides its table of contents into thirty parts, each of which might be considered a specialized branch of that vast science known as chemistry. One of these divisions is called Biological Chemistry which obviously means that it deals with the chemistry of biological reactions. Further examination shows that Biological Chemistry is a rather large division of *Chemical Abstracts* and that, in order properly to classify the literature, a number of subdivisions under Biological Chemistry have been made, one of which is called Nutrition.

Using the chemists' common weapon of analysis, it is found that, according to *Nutrition Abstracts and Review*, nutrition contains the following ingredients: technic, composition of foodstuffs, physiology, and diet in relation to disease (human and animal). On first thought, one might wish to divide the field of nutrition into two groups—human nutrition and animal nutrition. Further consideration, however, makes it apparent that the principles of human and animal nutrition are the same and that it is only in the application of these principles and in the technic of establishing them that any real difference exists. If, for instance, one were interested primarily in the physiology of nutrition, one might engage in a study of any of the following subjects and apply the results obtained to either animals or humans: enzymes, digestion, composition of body fluids and tissues, ductless glands and hormones, energy exchange and specific dynamic action, carbohydrate metabolism, protein metabolism, fat metabolism, mineral metabolism, and base equilibrium metabolism of water, metabolism of cells and tissues, rôle of different constituents of food in nutrition.

It should now be quite apparent that the field of nutrition is very extensive, particularly when it is considered that no specific mention has been made of that popular, much-worked phase dealing with the vitamins. Just how extensive this field is may be illustrated by two projects under way in this institution. One deals with the development of a system of raising calves that utilizes a minimum amount of milk; the other deals with the production of milk which will act as an antirachitic agent when fed to children. These are brief, simple statements; but, when the various angles involved are worked out and important ramifications that crop up as the work progresses are considered, the complexity of the original problem may be multiplied many times. One illustration will make this point clear.

The original problem of comparing the nutritive properties of milk produced by each of two groups of cows was presented. One of the steps in the comparison consisted of feeding rats nothing but milk from each of the two groups of cows. Rats are the common experimental test-tubes used in such work. In spite of the fact that milk had until then been considered a com-

plete feed, it was found that the animals fed exclusively on milk died within a few weeks. The cause of death was later shown, by studies of the blood picture, to be anemia. This fact was significant primarily because it demonstrated that with proper technic in handling the animals severe nutritional anemia could be produced in rats in a short time. It thus became a relatively simple matter to produce anemic rats for studies involving the treatment of this type of anemia. Pursuing the problem thus opened up, it was found that iron, previously considered the premier therapeutic agent in human anemias, was in itself ineffective in preventing milk anemia in rats. At another institution it was found that, when inorganic copper and inorganic iron were added to milk, anemia did not develop in rats fed such milk exclusively. In addition to establishing the fact that both iron and copper were essential in blood regeneration, this work suggested that milk was deficient in these two minerals. This led to analyses of milk for iron and copper. As a result, existing methods for iron and copper determinations in milk were found to be unsatisfactory, and new methods or modifications were attempted, leading finally to quite satisfactory methods.

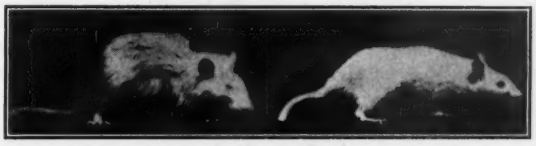
Another step in the comparison of the milks from these two groups of cows consisted of assaying them for vitamin A. In the course of this assay symptoms not previously described in the literature as accompanying vitamin-A deficiency were observed. The newly observed symptoms suggested some sort of muscular or nerve involvement. When resources which made possible the study of this new condition from an anatomical and pathological standpoint were brought into play, it was found that nerve degeneration which proceeds to the extent that muscular atrophy occurs in the afflicted area is one of the striking results of vitamin-A deficiency. In the course of this study an entirely new technic for studying nerve degeneration was evolved. In the new technic the fresh material is examined directly under polarized light, thus, eliminating tedious fixing and staining procedures.

From the foregoing illustrations it will be seen that the nutrition chemist must possess considerable training and experience. One of the most important lines of experience to be obtained concerns itself with the proper care and handling of experimental animals, remembering always that a biological response of an animal is as important as a chemical reaction in a test-tube.

As to the attractiveness of the field, a single word will express it adequately—fascinating. There is always a certain amount of routine, the amount depending upon the position one holds, but there are usually many different duties to be performed each day. Dullness does not exist except when one gets in a rut and makes no progress, and it is always with a keen sense of anticipation that one looks forward to the work of each new day.

[Work in the field of nutrition requires personal qualifications similar to those required in other fields of chemical research. Dr. Krauss has emphasized and illustrated the desirability of the following.]

As to personal qualification, assuming that the necessary pedantic and mechanical qualifications are satisfactory, there should be placed at the head of the list patience—patience to withstand disappointments when the first attempt is a failure, and patience to overcome the impulse to rush into print with data that have been insufficiently substantiated.



LEFT—A RAT FED ON AN EXCLUSIVE WHOLE MILK DIET; HEMOGLOBIN, 10 PER CENT. OF NORMAL. RIGHT—THE SAME RAT AFTER IRON AND COPPER ADDITIONS DAILY FOR TWO MONTHS; HEMOGLOBIN, 100, OR NORMAL

Honesty is a trait of character required in all lines of work, but it is particularly important in a field of work the object of which is to discover scientific truths. The temptation may be great at times to interpret data so as to favor a pet theory.

Diligence in this field is particularly essential. In so much of the work experimental animals are used which require feed and care every day of the year. A beginner in the field may be required to care for and feed his animals three hundred sixty-five days of the year. Later, as he advances in the field to the point where reliable assistants or students care for the animals, the routine of this daily vigilance is somewhat relieved, but not obviated.

Versatility is also a prime necessity. A simple animal cage may need to be designed and built, or some piece of apparatus not immediately at hand may need to be developed. A chemical determination may need to be made, an existing chemical method may need to be revised, or a new method developed; excreta from animals may need to be collected; post-mortem examinations may need to be made; scientific articles in foreign languages may need to be read; and scientific papers may need to be written.

IV. THE CHEMIST IN THE LEAD-SILVER SMELTER

FRANKLIN G. HILLS

For about thirty-five years, the contributor of this article, Mr. Franklin G. Hills, has been actively engaged as a chemist in the smelting and refining of ores. During the past eleven of these years he has been chemist at the Experimental Plant of the Colorado School of Mines.

He was graduated with honors from the New York College of Pharmacy. In addition he spent some time in Columbia University as a special student.

He is the author of several articles on chemical analysis and also a book, "Technical Analysis of Ores and Metal Products," which is being published by the Chemical Publishing Company.

✦ ✦ ✦ ✦ ✦ ✦ ✦

In the lead-silver smelter the chemist supplies the figures by which all operations are controlled. He also supplies the figures on which purchases and sales are made. The blast furnace slag must be analyzed probably twice a day. This requires speedy and accurate work. Speed and accuracy are not, as is sometimes thought, incompatible. Slow work does not of necessity imply accuracy, nor does speed imply rough or inaccurate work. Skill is required in the working laboratory, and the art of analytical chemistry is as important as the science. Both are necessary.

The chemist will receive, perhaps, as many as fifty samples from the roasters daily to be analyzed for sulfur, and samples of ores on which must be determined the elements necessary for settlement. The bullion and matte which are sold must be analyzed for the necessary elements, and full analyses are often required. Special problems are often presented and require both knowledge and skill for their solution. As an example, the writer was told by a plant manager late one afternoon that beginning the following day they were going to segregate bismuth-bearing ores on a basis of $^1/_{16}$ per cent. bismuth, and analysis would be required on every car of ore entering the plant in time to avoid demurrage.

A method was developed which proved an accurate one by which results were reported in ample time. As many as twenty samples were received in the afternoon on which bismuth was reported the following morning. This method has been successfully used in exacting work.

Industrial pressure is responsible for the development of many industrial methods which have been found to be, or have been developed into, very accurate methods. This industrial pressure is illustrated by an incident which occurred in a steel plant owned by Mr. Carnegie, who was the first man to employ a chemist in the steel industry. In the determination of phosphorus a gravimetric method was used and the result was not obtained until the day after the sample was received. At a certain plant improvements were being planned which would require results more promptly. The superintendent said to the chemist that he had to have phosphorus on those steels in two hours. "I can't do it," said the chemist. "There is no method known by which phosphorus can be done in any such time."

"I know that," said the superintendent, "but it is up to you to find a way. I must have those results in two hours."

As a result of such pressure, a steel chemist will now ordinarily have a phosphorus determination in one hour and on some steels in less than thirty minutes and it will be accurate. Variations in duplicate samples will not be more than 0.002 to 0.003 per cent. These samples illustrate the pressure brought on the chemist in industrial work.

It is necessary to adapt the job to the requirements. Methods are sometimes used which give only approximate results, but approximate results satisfy the requirements.

It is essential for one to realize the importance of time. For instance, fifty sulfur results done accurately would require all of one person's time for more than a day, but done accurately the results would be of no value, as they would be received too late to be of use to the plant. The metallurgist, in this case, is interested in approximate results within 0.5 per cent. These results can be given in a few hours. The writer has done seventy sulfurs, two complete slags, and a half dozen mattes in the forenoon, giving results that were satisfactory as a careful check has shown. This is an excessive amount of work, but it illustrates what can be done.

Analyses for purchase and sale of material are usually more exacting in their requirements. But these samples are being received daily, and it is necessary to do the work currently in order to avoid congestion. The shipper has his own chemist and the results from his laboratory and the smelter must practically agree in order to obtain a settlement. It is evident that the results must be correct or there will be extra work, for in case of disagreement the work must be repeated, and a number of repeats each day will increase the work materially. The results cannot be in any case better than the sample, and prompt approximate results which give the desired information are of more value than extremely accurate results which cause a waste of time with no corresponding advantage.

The importance of accuracy must not be minimized, but good technic is also of great importance. The function of the school is to transmit knowledge and to develop a good technic—but it does not have the facilities for developing the ability to handle a large volume of work. This ability can be acquired only in the industrial laboratory.

Ores are carefully sampled in the smelter for assay and settlement, but grab samples for various purposes are often submitted to the chemist. Results on grab samples are usually required and submitted with promptness. An extremely careful analysis on such samples is a waste of time for the chemist, and a source of annoyance to the metallurgist who is forced to wait for the results of the chemical analysis.

The smelter chemist will have a busy, exacting job, but it will be an interesting one. The doing of routine analysis is deadly unless he will follow up the application of his work to the plant operations. If he does this he will doubtless in time become the metallurgist himself, which involves routine work of another sort.

[Mr. Hills points out that the possession of degrees is not sufficient to assure success in the chemical profession.]

Of course, the man should know his chemistry, both theoretical and practical. The latter he may have to get on the job, but it is important. This does not mean necessarily the possession of advanced degrees. These are often a hindrance because the man who has them thinks they are synonymous with knowledge. Nothing could be farther from the truth. The most hopeless man with whom I ever worked had three degrees. A fourth would have ruined him. He had neither knowledge nor skill, but, because he had acquired his degrees, he felt that information from a more humble source was not worth his consideration. Degrees are rapidly losing their significance, especially to men who must deliver the goods. This does not undervalue advanced training; it means that much of the so-called training is inadequate.

[Mr. Hills is not the first contributor to mention the matter of honesty. However, because of his strong convictions on the subject, his comments are given below.]

Honesty is perhaps the most desirable qualification of any chemist. A dishonest chemist is almost unthinkable. In his work he should always report his result, right or wrong. Of course, for the most part his work must be right, but no man is infallible, and a chemical determination is a delicate operation. However, the chemist should never guess at a result. If there is doubt as to its accuracy he must repeat. Get the truth before reporting, or tell the interested party of the question, if difficulties are encountered.

One of my assistants told me that his professor would have nothing to do with a man whom he once caught in a dishonest act. I believe that idea to be fundamentally correct. Incidentally, to my personal knowledge, that particular school has produced some real chemists.

V. CHEMICAL RESEARCH IN THE GLASS INDUSTRY

WILLIAM J. ARNER

Some of the problems confronting a chemist employed by a company manufacturing all kinds of flat glass are presented by Dr. William J. Arner of the Libby-Owens-Ford Glass Company.

He is a graduate in metallurgical engineering from Lehigh University and received the degrees of M.S. and Ph.D. from the University of Chicago. Dr. Arner is the author of several papers describing the results of his research.

✦ ✦ ✦ ✦ ✦ ✦

Safety glass is made of two thin plates of glass between which is sandwiched a layer of a flexible, transparent, organic material. The safety glass first manufactured presented a problem, being subject to the defect that it became yellow with age. This was not only unsightly, but, as the glass aged, it was no longer as well bonded and so not as great a protection against the hazards of flying glass as when originally made.

The problem then was this: What was the cause of this aging and how could it be overcome? First, there was the organization and consideration of the facts known of the nature of the intermediate or plastic layer and of the glass layers. These facts had been accumulated from physical tests in our laboratory and from existing and available literature. From these facts, it was evident that the plastic layer of nitrocellulose, which is inherently unstable to energies in the form of light and heat, was the thing most at fault and ultimately would have to be replaced. At the time the problem presented itself, there was available commercially, in a form suitable for use in this laboratory, nothing other than nitrocellulose plastic. Some work had been done on nitrocellulose plasticized with materials other than camphor, but tests of these materials showed that while they offered some improvement, it was not enough.

The field for development of a plastic to replace one of nitrocellulose was unusually broad and included other cellulose derivatives, natural and synthetic resins, gelatin products, casein, and rubber derivatives. A careful examination of the field resulted in the choice of a cellulose acetate plastic, because in addition to the fact that it would undoubtedly be more stable to light and heat energies, and possess other desirable characteristics, it offered the most promise of ready availability.

Availability in this case meant at a price near that of the material it was to replace and in sheet form suitable for use. At this stage of the operation it was necessary to obtain first the coöperation of the manufacturers of cellulose acetate and then to sell this idea to the somewhat conservative plastic manufacturers in order to get plastic sheets of cellulose acetate available for tests.

To obtain suitable plastic sheets required the cooperation of organic, glass, and physical chemists. It is necessary for any well-organized industrial research laboratory to have a similar coöperating group in order to solve industrial research problems.

The mere development of a satisfactory cellulose acetate plastic sheet by no means solved the problem. The next and probably the most difficult step was to make an adhesive which would bond glass and cellulose acetate plastic. This step required the organized efforts of both physical and organic chemists for over one and one-half years. While this part of the problem was purely scientific, commercial and engineering development aspects must be considered at every step, for to make a good adhesive or plastic prohibitive in price is little better than not to make any at all.

Then, when a better safety glass had been developed, engineering and commercial developments were necessary. The manufacture of the new product next had to be taken over by the plant, after quite accurate estimates of production costs and machinery changes or replacements had been made by the research organization. For successful operation, chemical and physical controls had to be supplied to the plant and after that the research organization had to see, initially, at least, that these controls were rigorously applied. And, of course, the advertising and sales departments had to be supplied with all pertinent information necessary for selling the product after it had been made.

The research department could then proceed to the solution of new major problems and a mass of accumulated minor problems.

No problem, not even one of a minor nature, is solved by one man alone but by the organization, individuals solving only certain aspects of the problem.

EXAMINATION PRACTICE *in* GENERAL COLLEGE CHEMISTRY

B. CLIFFORD HENDRICKS
University of Nebraska, Lincoln, Nebraska
AND
BENJAMIN H. HANDORF
Park College, Parkville, Missouri

THERE is probably no institution which offers general college chemistry which does not set examinations for the students in the course. It is of interest and of value to know just what the practices of different institutions are in preparing and administering such tests.

With a view to gathering such information one of the authors sent out a request for typical examination questions for both first and second semesters in the spring of 1936. The response of interested teachers of college chemistry to that request and to a similar solicitation by Dr. O. M. Smith of the A. C. S. Committee on Examinations placed some fifty sets of tests for each semester at the disposal of the authors. They recognize that fifty is not an adequate sampling for a dependable composite picture of examination practices in college chemistry. However, they do consider the inventory as a possible index of trends of such practices in colleges.

Three approaches have been used in the study. First, the tests were inspected in an effort to check objectives, many of which chemistry teachers had previously professed[1] to follow in the course in general college chemistry. Second, the tests for the second semester were analyzed in order to determine subject-matter areas included. Second-semester, rather than first-semester, examinations were used for this purpose because it was assumed that there would be a better agree-

[1] SMITH, O. M., "Accepted objectives in the teaching of general college chemistry," J. CHEM. EDUC., **12**, 180–3 (Apr., 1935).

ment among different institutions upon second- than upon first-semester subject matter. Third, miscellaneous information in regard to form of questions, number of questions, options, etc., was secured.

Most objectives of a chemistry course may be made measurable[2] by a proper attention to the formulation of them. A survey of the examinations of teachers of general college chemistry may help to show whether such teachers consider *their* objectives measurable. Such a survey may also show whether there is any difference between the first- and second-semester examinations with regard to the character of the aims or the stress of these aims; further, "Does this stress in the examinations correlate well with the stress expressed by teachers in their choice of objectives?" The following table offers tentative information relative to these points.

TABLE 1

ANALYSIS OF EXAMINATIONS IN TERMS OF OBJECTIVES MEASURED

Semester	*First*		*Second*		
Number of test sets	48		46		
	*Frequency**	*Stress†*	*Frequency*	*Stress*	*Per Cent. of Teachers Preferring This Objective*
Objectives listed					
1. Use of symbols and formulas	48	12	100	45	
2. Terms defined	83	15	66	15	
3. Facts remembered	100	70	100	100	67
4. Laws and principles stated	75	10	23	10	82
5. Laws and principles applied	100	40	90	30	80
6. Conclusions from data	7	10	19	10	81
7. Formulating and testing hypotheses					52
8. Use of library					45

* Per cent. of the total examinations containing questions upon this objective.

† Median per cent. of examination units containing questions upon this objective.

In order to estimate the extent to which a given objective functioned for an examination analyzed, each examination set was canvassed to ascertain the number of its requirements which called for responses in line with that particular aim. After that canvass was completed those results were expressed as per cents. of the total number of requirements for each examination set. To get a composite for all sets, a distribution sheet was charted of these per cents. for each objective and the median of that distribution taken as an index of the emphasis which those examinations placed upon that objective.

In determining the median per cents. only those examinations were considered which had one or more units which tested for the objective under consideration. The number representing the median per cent. has such a value that the number of examinations having a *larger* per cent. of units given to that objective was equal to the number of examinations giving a smaller per cent. of units to it.

As an illustration, item number 4 in Table 1 means that seventy-five per cent. of the forty-eight first-semester examinations required the statement of laws or principles and that that requirement was found to be ten per cent. of the questions in those examinations as a median for all in which it occurred. However, only twenty-three per cent. of the forty-six sets of second-semester tests contained such a requirement though, as in the first semester, questions testing that objective constituted ten per cent. of all questions as a median for all tests using it. The fifth column of the table states eighty-two per cent. of the teachers of general college chemistry in 1935 approved that as a desirable objective.

Some implications of this table should be noted. The second semester shows a larger per cent. of the examinations, including symbolism in some form. Likewise a greater per cent. of the questions require a knowledge of symbolism than those of the first semester. The call for definitions is in more first semester examinations and constitutes a greater per cent. of the first-semester questions than of the second semester. It is of interest to note that a larger per cent. (one hundred) of the examinations demand facts than teachers (sixty-seven per cent.) considered desirable in their professed objectives of chemistry. The memory element, however, is less emphasized in the second semester. On the other hand, more teachers (eighty-two per cent.) stressed a knowledge of laws and principles in their objectives than actually (seventy-five per cent. and twenty-three per cent.) called for them in the questions examined. One of the agreeable surprises, to the authors, was the almost unanimous inclusion of requirements for application of principles. One would expect that objective to be more generally used the second semester than the first; such was not realized in the examinations inventoried. Quite in contrast is the profession of eighty-one per cent. of the teachers that they aim to train their students to be able to draw conclusions from given data, but less than ten per cent. of their examinations reveal any such requirements. Equally disappointing is the total absence of any attempt to locate; ability to formulate and test hypotheses or skill in using the library as a source of information even in the face of a forty-five per cent. or more demand of teachers for such objectives in the list of course aims.

In the analysis of the second-semester examinations for subject-matter spread the classification used was that of the Report[3] of the Committee on Correlation of High-School and College Chemistry.

As a standard for comparison purposes a survey was made of five representative textbooks of college chemistry using the same classification of subject-matter areas as that to be used in the inventory of the examinations. It was assumed that the number of pages of text devoted to a given area of subject matter was an index of the author's stress of that topic. Table 2 gives the result of the survey for nine topics chosen from second-semester subject-matter content.

[2] HENDRICKS, B. CLIFFORD AND O. M. SMITH, "Measurable objectives for general college chemistry," *Sch. Sci. Math.*, **36**, 747–52 (Oct., 1936).

[3] "Correlation of high-school and college chemistry," J. CHEM. EDUC., **4**, 644–56 (May, 1927).

TABLE 2

DISTRIBUTION OF SUBJECT MATTER IN TEXTBOOKS OF CHEMISTRY[4]

Text Involved	*Structure of Matter*		*Periodic*		*Sulfur*	*Phosphorus*	*Carbon*			*Total Pages*
	General	*Ionogens*	*Classification*	*Halogens*	*Group*	*Group*	*and Organic*	*Metals*	*Colloids*	*Counted*
A, Pages	91	55	9.5	37	37	49	97	120	13	453.5
Per cent.	20.8	12.1	2.1	8.2	8.2	10.8	21.4	26.5	2.9	
B, Pages	50	29	10	37	27	58	79	150	19	430
Per cent.	11.6	6.7	2.3	8.6	6.3	13.5	18.4	34.8	4.4	
C, Pages	56.5	24	11	36.5	28	48	107	182	12	481
Per cent.	11.7	5.0	2.3	7.6	5.8	10.0	22.2	37.8	2.5	
D, Pages	62	43	10	54	36	50	100	169	1	482
Per cent.	12.9	8.9	2.0	11.2	7.5	10.4	20.4	35.1	0.2	
E, Pages	72	34	17	40	34	65	97	190	9	524
Per cent.	13.7	6.5	3.3	7.6	6.5	12.4	18.5	36.3	1.2	
Totals	331.5	185	57.5	204.5	162	270	480	811	54	2370.5
Per cent. of the pages to each topic	14.0	7.8	2.4	8.6	6.8	11.4	20.2	34.2	2.3	99.9

The technic used in getting indices of *subject-matter-use* and *subject-matter-stress* in the analysis of the subject matter of the second semester was that previously described for tabulation in Table 1. In interpreting the data of Table 3 it must be borne in mind that any given examination question may include several "items." To illustrate, in classifying the "items" from the question, "Describe the ordinary test for the chloride ion," silver, chlorine, and the structure of matter would each be credited with items for this requirement.

In general, in interpreting Table 3, the first column gives an index of how generally the subject-matter from that area is used in the examinations; the second column is a rough estimate of the stress which the users of that topic are giving it in their examinations and the third column is a scale of the importance attached to that type of chemical information by authors of textbooks. This third column data is brought forward from Table 2.

TABLE 3

SUBJECT-MATTER COVERAGE BY SECOND SEMESTER EXAMINATIONS

Areas of Subject Matter	*Frequency Stress*	*Text Stress*	
1. Structure of matter	93†	15*	14.0‡
A. Reactions involving structure	65	1	
B. Ionogens	80	2	7.8
2. Periodic classification as a principle of inorganic chemistry	39	2	2.4
3. Halogen group	91	5	8.6
4. Sulfur group	100	25	6.8
5. Phosphorus group	96	10	11.4
6. Carbon group including organic chemistry	96	10	20.2
7. Metals (as a group)	100	25	34.2
8. Colloidal chemistry	28	1	2.3

* Of those examinations containing this item a median of fifteen per cent. of all requirements were for information in structure of matter.

† Ninety-three per cent. of all sets examined contained some demand for a knowledge of the structure of matter involving some one or more of the molecular, atomic, ionic, or electronic theories.

‡ Five leading textbooks devote fourteen per cent. of second semester pages to structure of matter.

After an inspection of the above summarization one wonders if the sampling of the subject matter for second-semester examinations is a conscious process upon the part of the examiners. Do they intentionally give colloidal chemistry scant attention? Do they by their stress of the sulfur group mean to consider it of superior importance to the phosphorus group including, as it does, all of inorganic nitrogen chemistry? Does the less than fifty per cent. inclusion of test items upon the periodic principle, as such, mean that generally that is a first-semester topic, or does it mean that the teachers of general college chemistry would minimize its importance in their courses? The authors have heard many protests from teachers that organic chemistry should receive less stress in general chemistry, yet here we find it among the "big five" as to stress in examinations and among the "big four" as stressed by the text-book authors.

The form of the examination, the plan for administering it, the number of items or requirements in it are, as would be expected, variables. Of the second-semester examinations canvassed, thirty-seven per cent. offer options; the per cent. was twenty-seven for the first semester. These are sometimes options involving whole questions; at other times they permit choice of parts within the question. College teachers of chemistry, in practice, do not agree with the statement,[5] "Teachers interested in improving essay examinations should eliminate optional or alternate questions."

The number of questions constituting an examination varied all the way from five to three hundred eleven with a median of ten for the first-semester examinations. Tabulation for "items" in the second-semester examinations gave a spread from 31 to 344 with a median of 120. It would seem that there is no general agreement as to what constitutes an adequate sampling of subject-matter for a valid examination. Another interesting bit of information which the survey revealed was that these forty or more teachers do not, in practice, attempt a comprehensive examination of the whole year's work in general chemistry.

With a view to learning of probable future practice in this phase of teaching, "What do these teachers think of their present examinations?" In a questionnaire which forty teachers returned with their examination sets, thirty-two per cent. of them said they were satisfied with their present examinations. That statement also means that there are sixty-eight per cent. of these teachers looking for a better way to measure student progress and achievement. Some of that sixty-eight per cent. are attempting to do something to improve the

[4] Textbooks used were: DEMING, "General chemistry," 4th ed.; HOLMES, "General chemistry," revised ed.; MCPHERSON AND HENDERSON, "General chemistry," 4th ed.; RICHARDSON, "General chemistry," revised ed.; KENDALL-SMITH, "College chemistry."

[5] STALNAKER, J. N., "Should optional questions be used in examinations?" *Sch. & Soc.*, **42**, 644–7 (Nov. 9, 1935).

present unsatisfactory practices. The following tabulation, Table 4, is an attempt to show how variable the form of the requirements are, and possibly indicates some experimentation by these teachers in an attempt to improve their examinations.

TABLE 4
TYPES OF TEST QUESTIONS USED FROM FORTY-SIX SETS OF SECOND-SEMESTER EXAMINATIONS

Kind of Response	*Frequency*	*Stress*
Essay	91	70
Completion	63	20
Master list	15	20
Multiple-choice	20	20
True-false	13	20
Problems	32	15
Equations	98	35

It is evident, from the above, that teachers of college chemistry are not unanimous in their objection[6] to new type test forms. Perhaps, to many, it will be a surprise to learn that there were actually four whole semester examinations in which there was not a single essay question and there was one examination which called for no equations. The generous use of equations and the stress they receive in examinations does not receive universal approval. The authors are not alone in their opinion that teachers of chemistry have far more confidence in the equation as an index of chemical achievement than a disinterested study of the matter would warrant. One writer[7] states, "It would not . . . be safe to say that . . . ability in (writing) chemical equations predicts chemical knowledge."

The use of problems as indexes of chemical progress has its critics.[8] The use of problems as a part of the examinations is not as prominent as some may have anticipated.

[6] HOYT, W. F., "Methods of testing—a criticism," J. CHEM. EDUC., **4**, 1414–8 (Nov., 1927).
[7] HUTCHINS, R. B., "The value of tests in writing chemical equations," *ibid.*, **3**, 915–9 (Aug., 1926).
[8] HENDRICKS, B. CLIFFORD, "New type tests meet a need," *ibid.*, **4**, 1420 (Nov., 1927).

Many examiners probably used the completion type of response unwittingly, which accounts for the occurrence of that type of requirement in sixty-three per cent. of the tests. When equations are to be completed, or balanced, or when formulas are given with their chemical names desired, or *vice versa*, such requirements are just as truly the completion type as when a paragraph is mutilated by omissions to be filled by the writer of the examination. There was unmistakable evidence of the influence of the Coöperative Test examinations in the forms of test requirements used in many of the examinations. However, the type of question used generally began with: "explain," "describe," "outline," "discuss," "define," "state," or "account for." As a close second, and creeping into every third question, comes the call for an equation.

What, in brief, seems to be the character of the general college chemistry examination? It stresses factual information with a gratifying emphasis upon application rather than the statement of laws and principles. It has a large place for symbolism in its make-up, especially using the equation as a measure of chemical achievement. Many examiners forget part of their objectives when they write examination questions. Such omissions include: ability to draw conclusions from data, or to form and check-up hypotheses or to use the library as a source of data. In subject-matter areas, their stress is surprisingly similar to that of leading textbook writers. These examinations are generally ten questions long and contain approximately one hundred or more items. Every third examination set will permit student choice of questions to be answered. Sixty-five per cent. of the teachers responding to the question confessed to the occasional use of old questions, and sixty-eight per cent. of them say they are not satisfied with their examinations. The chief complaint is that the examinations are too largely tests of memory rather than tests of ability to interpret and apply the facts and principles of chemistry.

A SATISFACTORY METHOD OF GENERATING HYDROGEN SULFIDE

V. T. JACKSON AND F. C. SUHRER
University of Florida, Gainesville, Florida

HYDROGEN sulfide is a necessary nuisance around the analytical laboratory. Tubes conveying it frequently leak, and the poisonous nature of the gas sometimes overcomes students. It has been known for some time that a mixture of paraffin and sulfur can be purchased under the name of "aitchtuess." This, when heated, evolves hydrogen sulfide.

We have found that if a mixture of equal parts of rosin and sulfur are mixed and heated in a test-tube, hydrogen sulfide is easily evolved. It is not necessary to grind the substances finer than to pass a 20-mesh sieve. If one gram of each of the substances is used, the quantity of gas liberated is sufficient for an ordinary analytical precipitation. The carbon residue is rather friable and easily removed.

A PERIODIC SYSTEM *of the* ELEMENTS

E. C. PAYNE*
Villa Park, Illinois

A somewhat original Periodic System is presented, consisting of an octagonal cardboard prism, its faces divided into rhombs by a descending helical band. Each rhomb is assigned to an element. The distinction between the two families of each column of the Mendeléeff chart (e. g., Li and Cu families) is clarified by elevating one of them (Cu family) above the surface of the prism, and connecting these raised spaces to form a continuous series (e. g., Sc through Zn series). The metallic triads of column 8 occupy the faces of parallelepipeds, set upon rhombs in column 8. The rare earths appear on the inside surface, through a window cut where space 57 would be.

After speculation upon the nature of the last, unfinished period, there is listed an opinion of the principal difficulties and pitfalls encountered in the construction of an original periodic system.

✦ ✦ ✦ ✦ ✦ ✦ ✦

THE number of articles on the periodic system which have appeared in THIS JOURNAL in recent years, and especially that series by Quam and Quam,[1] during 1934, have stimulated the author to a fresh study of that classification. While no system which has been devised is perfect, some of them do express the relations of the elements in such clear and usable form that any further arrangements might seem like new proofs of the Pythagorean proposition of geometry, demonstrating the ingenuity of the inventor, rather than adding to useful scientific knowledge. There is, however, a justification for such a work. That is the stimulation of student interest in this key to inorganic chemistry. That it should occupy a prominent place in the course in general chemistry is universally admitted. Nevertheless, its potentiality as a guide to the chemistry of the elements often is not effectively utilized in pedagogical practice. It should be introduced early in the course, as soon as the elements are taken up by families, and their relations discussed. Later, when the student has learned a little of atomic structure, his introduction to a number of periodic systems serves to stimulate his interest in the relations of the elements, and the resultant study will lead toward the integration of the chemistry which he has learned, or may learn. He may even be sufficiently interested to attempt an arrangement of his own. In laboring over this fascinating and intricate puzzle, he cannot fail to learn a great deal of chemistry, in addition to fixing the system firmly in his memory, even though failing to produce a creditable original scheme.

FIGURE 1

Probably no system yet published approaches in usefulness the modified Mendeléeff chart. In spite of some theoretical objections, it remains the clearest and most convenient for general classroom use. Some of the systems which seem better from the theoretical

* Former address Butler University, Indianapolis, Indiana.

[1] QUAM, G. N. AND M. B., THIS JOURNAL, 11, 27, 217, 288 (1934).

point of view, such as the helixes of Harkins-Hall[2] and of Schaltenbrand,[3] lack clarity and ease of comprehension.

The author ventures to present a system incorporating something of the graphic clarity of the simple Mendeléeff chart, with the theoretically nicer arrangement of the three-dimensional models. It incorporates the basic principles of the Harkins-Hall

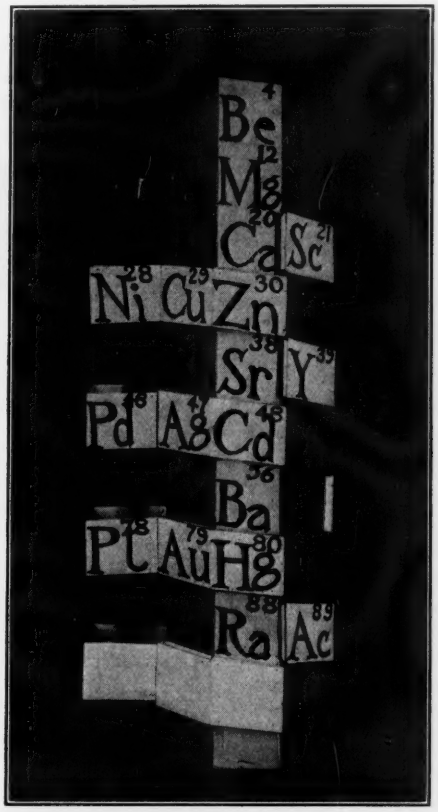


FIGURE 2

helix and of the "castle" of Courtines.[4] It is constructed of cardboard in the form of an octagonal prism. A ribbon is wound spirally about this figure, barber-pole fashion, dividing its faces into rhombs. The "pitch" of the spiral is such that, upon completion of the circuit, the ninth rhomb falls just below the first.

The topmost space, thus set off, is occupied by helium; the other elements following, in order of their atomic numbers, upon the successive spaces of the descending screw. The back face of the helium rhomb is occupied by hydrogen, as in Courtines' model. This face is a separate card, hinged at the top, so that it may be raised above He, and thus be more easily visible. With H folded back in its normal position (not shown in illustration), the H-He pair is seen to compose a compressed period, with hydrogen occupying a place similar to that of the whole Li-F series. Hydrogen does exhibit some properties similar to those of lithium and of fluorine, but few like those of the intervening elements. The reason for this, of course, is its single external electron. The second series begins with neon, which lies just below helium, and ends with chlorine.

The third begins similarly with argon, but is interrupted abruptly after calcium, due to the inter-

FIGURE 3

position of a series of elements somewhat dissimilar to those of the Al, Si–Ca sequence. In order to emphasize the distinction of this, the scandium series, from the preceding ones, it is placed upon a raised ribbon; *i. e.*, one which is wound about a slightly

[2] HARKINS AND HALL, *J. Am. Chem. Soc.*, **38**, 169 (1916).
[3] SCHALTENBRAND, THIS JOURNAL, **11**, 293 (1934).
[4] COURTINES, *ibid.*, **2**, 107 (1925).

larger, concentric prism. Upon reaching Fe, the ribbon buckles, and the elements of the iron triad appear upon the vertical faces of a parallelepiped which is set upon the space just below that of argon. The series continues through zinc.

Beginning with gallium, we drop back to the lower level, continuing through strontium. Then there follows another "raised" series, yttrium through cadmium, exactly similar to the first. Again descending to the level of the basic prism, we find the indium-barium series.

FIGURE 4

We are then confronted by the rare earth pleiad. We seem to need another dimension, in order to represent the position of this group. The problem of its logical and symmetrical arrangement has not been satisfactorily solved. The symbols of these elements are painted upon a strip of cardboard, allotting each element about half as wide a space as that of the other elements. The space following barium is cut out, forming a window, and the strip inserted after bending to follow the contour of the internal wall. It is held in place by tabs on the inside, allowing it to be removed for inspection.

After the rare earths, the high level series continues, to end with mercury. There follows the last low-level series, thallium to radium. There is some doubt as to the nature of the final period, beginning with virginium and ending, unfinished, with uranium, or possibly with No. 93. Just now it appears that it is another "18" period, like that of Rb-Xe. In this model that is assumed to be the case, and the final high level series begins with actinium and ends with No. 98, after six blank spaces.

If this were another "32" period, like its predecessor (La-Hg series) we should, by analogy, have a pleiad like that of the rare earths, where actinium now stands.

FIGURE 5

If so, the elements Th to U now have incorrect atomic numbers. The Bayley-Thomsen-Bohr chart[5] seems to provide for such a pleiad in space No. 96, which would effect an unsymmetrical arrangement in most other systems. It seems idle, however, to speculate further upon the nature of elements undiscovered and unlikely, it seems, to be discovered.

The creation of a perfect periodic arrangement of the elements is, doubtless, an impossible task. If there is an exact mathematical relation between the chemical and physical properties of the elements, it is an obscure and an extremely complex one. The author, seeking to improve the present systems, should bear in mind certain well-recognized pitfalls and difficulties, some of which are listed below.

1. There should be a space provided for every valence form of each element, for these forms differ as much from one another as from other elements. However, this would unduly complicate a chart to be used in the classroom, and might best be worked by means of a series of charts.

2. The position of hydrogen, and its relation to the members of the Li-F series should be shown.

3. The similarities and differences between the right and left (A and B) families of each column of the modern Mendeléeff chart should be shown. For example, in the first column, the alkali family possesses properties contrasting sharply with those of the copper family. However, in the univalent condition there are certain similarities, for instance, in the basicity of their hydroxides; again, in the atomic number—ionic radius curve, similar cusps are formed with K,

[5] CLARK, "The basis of the modern atomic theory," frontispiece, Methuen and Co., London, 1925.

Cu, Rb, Ag, Cs, and Au occupying the successive peaks.

In the beryllium family, a more or less sharp break occurs between Mg and Ca. Nevertheless, there is a continuous gradation in properties from Be to Mg to Ca: amphoteric, weakly basic, strongly basic. If Zn and Cd were included in this family, there would be a retrogression: basic to amphoteric to basic.

Similarly, Sc and Y belong to a family distinct from that including B, Al, Ga, In, etc., and Ti, Zr, Hf, Th form a group separate from that including C, Si, Ge, and Sn.

4. The similarities of the members of the horizontal sequences, as:

V, Cr, Mn, Fe, Co, Ni, Cu, Zn,
Cb, Mo, Ma, Ru, Rh, Pd, Ag, Cd,
Ta, W, Re, Os, Ir, Pt, Au, Hg, etc., should be perceptible.

5. The great differences between the noble gases and the three triads of metals of column 8 should be shown, while attention should be directed to their similarities in electronic structure, as shown in the octavalent compounds of Ru and Os, and perhaps of Fe, Co, and Ni, in which the presence of an octet of electrons is demonstrated.

6. There should be a reasonable place for the rare earth elements. They should not be assigned a single place in the Mendeléeff-type chart, nor to a single vertical column, as in the Harkins-Hall model; for this would consign them to a position exactly similar to that of the isotopes of a single element.

7. There should, in so far as possible, be shown the nature of the unfinished series beginning with element 87 (virginium), and ending, apparently with uranium, or its successor.

HISTORICAL MATERIALS *in* COLLEGE GENERAL CHEMISTRY TEXTBOOKS

RALPH E. DUNBAR

North Dakota Agricultural College, Fargo, North Dakota

THE use of historical material as an effective approach to the study of numerous topics in general chemistry has long been recognized by most teachers and textbooks writers. However, even a casual examination of representative texts reveals a wide variation in the nature and extent of such materials included. The present study was undertaken to determine the type and amount of such historical materials contained in several representative college general chemistry textbooks. It is believed that the findings may be useful to instructors in planning their courses. Frank and Lundsted[1] have made a similar study of high-school chemistry texts and certain comparisons will be made between the two investigations. The plan of study and classification is essentially the same in the two reports. A page-by-page examination was made of the following twenty textbooks and all historical references noted, classified, and tabulated.

In this study, as in the previous investigation,[1] all items relating to chemical history may be classified as brief accounts of the development of modern chemistry from alchemy and the older mixture of fact and superstition which preceded it; short historical items, related to the discovery of an element or development of a law or theory, which are scattered throughout the texts; short mention of the names of important persons in chemical history; brief biographical accounts; and cuts of men and historical laboratories and apparatus. None of the twenty texts studied presents a complete or consistent history of the development of chemistry, although all make some reference to this early period of investigation. One of the books lists, in its appendix, the winners of the Nobel prize in Chemistry from 1901 to 1935 inclusive, with the country of residence and important contributions. The number of words used to present the historical aspects of chemistry range from 920 to 26,773 in the twenty texts surveyed. While this is an enormous range there appears to be little, if any, correlation between the amount of historical material included and the date of publication of the several texts. At least there is no

[1] FRANK, J. O. AND LESTER LUNDSTED, "Historical materials in high-school chemistry texts," J. CHEM. EDUC., 12, 367–9 (Aug., 1935).

noticeable increase in recent years for the first ten textbooks, all published before January 1, 1931, contain an average of 9040 words devoted to historical material, while the ten published since that date have an average of 6473 words. However, these averages are greatly influenced by the high values of the texts by Timm and Richardson.

TABLE 1

LIST OF BOOKS EXAMINED

(1) BLANCHARD, WILLIAM MARTIN, "An introduction to general chemistry," Doubleday, Doran & Company, Inc., Garden City, New York, 1928.
(2) BOND, PERRY A., "The fundamentals of general chemistry," Farrar & Rinehart, Inc., New York City, 1935.
(3) BRINKLEY, STUART R., "Introductory general chemistry," The Macmillan Company, New York City, 1932.
(4) BRISCOE, HERMAN T., "An introduction to college chemistry," Houghton Mifflin Company, New York City, 1937.
(5) CARTLEDGE, G. H., "Introduction to inorganic chemistry," Ginn and Company, New York City, 1935.
(6) DEMING, HORACE G., "General chemistry," John Wiley & Sons, Inc., New York City, 1935.
(7) FOSTER, WILLIAM, "The elements of chemistry," D. Van Nostrand, Company, Inc., New York City, 1932.
(8) GORDON, NEIL E., "Introductory college chemistry," World Book Company, Yonkers-on-Hudson, New York, 1926.
(9) HOLMES, HARRY N., "General chemistry," The Macmillan Company, New York City, 1936.
(10) HOPKINS, B. SMITH, "Essentials of college chemistry," D. C. Heath and Company, New York City, 1932.
(11) KAHLENBERG, LOUIS, "Outlines of chemistry," The Macmillan Company, New York City, 1918.
(12) KENDALL, JAMES, "Smith's introductory college chemistry," The Century Company, New York City, 1931.
13) MCCOY, HERBERT N. AND ETHEL M. TERRY, "Introduction to general chemistry," McGraw-Hill Book Company, Inc., New York City, 1920.
(14) MCCUTCHEON, THOMAS P. AND HARRY SELTZ, "General chemistry," D. Van Nostrand Company, Inc., New York City, 1927.
(15) MCPHERSON, WILLIAM AND WILLIAM EDWARDS HENDERSON, "An elementary study of chemistry," Ginn and Company, New York City, 1934.
(16) NEWELL, LYMAN C., "College chemistry," D. C. Heath and Company, New York City, 1925.
(17) RICHARDSON, LEON B., "General chemistry," Henry Holt and Company, New York City, 1927.
(18) SCHLESINGER, H. I., "General chemistry," Longmans, Green and Co., New York City, 1930.
(19) SNEED, M. CANNON, "General inorganic chemistry," Ginn and Company, New York City, 1926.
(20) TIMM, JOHN ARREND, "An introduction to chemistry," McGraw-Hill Book Company, Inc., New York City, 1930.

Short historical references are frequently made in connection with the discovery of important facts or laws. The consistency is not all that might be desired. The topics most often treated historically are as follows.

The discovery of helium in all twenty texts.

The discovery of argon and the other inert gases of the atmosphere are mentioned, in more or less detail, in nineteen of the books studied.

The history of the periodic table appears in eighteen of the textbooks.

The discovery of oxygen, especially as related to the work of Lavoisier and Priestley, appears also in eighteen of the texts.

A discussion of the discovery of radium and other related radioactive elements is included in seventeen of the college textbooks.

The number of biographies, either brief or extended, in the twenty texts range from 0 to 29. A total of eighty-three biographical accounts of forty-six different persons are included. These accounts usually consist of name, date of birth and death, and some brief mention of important chemical contributions of the individual.

Twelve of the twenty textbooks show cuts of men who have made important contributions to chemistry. These pictures vary from one-sixth to full page size. A total of one hundred seventy portraits of sixty-nine different chemists appear in the twenty books. The range is from 0 to 29. Cuts of historical laboratories, pieces of apparatus of historical significance, and alchemical laboratories are included in eighteen of the twenty textbooks included in this study.

The facts mentioned above are briefly summarized in Table 2.

TABLE 2

ANALYSIS OF TWENTY COLLEGE GENERAL CHEMISTRY TEXTBOOKS

Author of Textbook	*Words in Historical Accounts*	*No. of Names*	*Biographies*	*Portraits*	*Historical Cuts*
Timm	26,773	226	5	7	5
Richardson	18,897	164	2	8	3
Holmes	11,743	216	2	3	8
Sneed	9,713	241	0	12	2
Foster	9,652	179	18	18	7
McPherson & Henderson	9,390	101	29	29	5
Kahlenberg	7,738	196	0	0	3
Brinkley	7,638	141	12	13	4
McCoy & Terry	7,194	112	0	0	4
Briscoe	7,179	113	0	0	4
Blanchard	6,319	107	11	11	3
Schlesinger	6,291	96	0	0	0
Deming	5,972	79	0	0	2
Bond	4,889	102	0	0	3
Cartledge	3,725	98	0	23	1
Newell	3,380	83	0	27	5
Kendall	3,353	84	2	2	3
Gordon	3,175	62	2	17	2
Hopkins	1,193	51	0	0	1
McCutcheon & Seltz	920	65	0	0	0
Total	155,134	2516	83	170	65
Total (minus duplications)	—	667	46	69	37

It will be observed that the text by Timm contains the largest number of words in the historical account. This may perhaps be explained in part by the obvious attitude of the author. In the preface he offers four objectives in outlining the subject matter of this textbook, the fourth of which is, "to treat the development of the theory from an historical point of view in so far as is consistent with a presentation of the subject matter which is pedagogically sound."

A total of six hundred sixty-six different names are mentioned in the twenty texts. There are five hundred thirty-four names which occur five times or less and three hundred forty-two names which occur but once. There are only seventy-three names which are mentioned in more than half of the books. Only four names are mentioned in all of the books. The range of names mentioned varies from two hundred forty to fifty-one. It is interesting to note that the rank in number of names included does not coincide perfectly with the order of words in the historical accounts. A list of all names, together with the number of books in which each name is mentioned, is given in Table 3.

TABLE 3

NAMES MENTIONED IN COLLEGE GENERAL CHEMISTRY TEXTBOOKS

Name	No. of Books
Avogadro	20
Bessemer	20
Boyle	20
Dalton	20
Bunsen	19
Davy	19
Frasch	19
Gay-Lussac	19
Lavoisier	19
Mendeléeff	19
Scheele	19
Solvay	19
Becquerel	18
Charles	18
Faraday	18
Haber	18
Le Chatelier	18
Ramsay	18
Rayleigh	18
Arrhenius	17
Curie, Mme.	17
Glover	17
Le Blanc	17
Lewis	17
Moseley	17
Parke	17
Rutherford	17
Birkeland	16
Eyde	16
Graham	16
Hall	16
Henry	16
Moissan	16
Newlands	16
Priestley	16
Bohr	15
Cavendish	15
Daniell	15
Dewar	15
Fehling	15
Goldschmidt	15
Langmuir	15
Lockyer	15
Meyer, Lothar	15
Acheson	14
Aston	14
Curie, Pierre	14
Glauber	14
Millikan	14
van't Hoff	14
Wöhler	14
Berzelius	13
Brown	13
Crookes	13
Dobereiner	13
Dulong	13
Marsh	13
Nelson	13
Ostwald	13
Petit	13
Castner	12
Claude	12
Heroult	12
Kipp	12
Thomson	12
Ballard	11
Dakin	11
Deacon	11
Laue	11
Raoult	11
Richards	11
Tyndall	11
Welsbach	11
Bragg	10
Brand	10
Cannizzaro	10
Courtois	10
Black	9
Cottrell	9
Deville	9
Edison	9
Guldberg	9
Janssen	9
Liebig	9
Prout	9
Roentgen	9
Soddy	9
Stahl	9
Stas	9
Turnbull	9
Waage	9
Berthollet	8
Bredig	8
Chaptal	8
Clarke	8
Debye	8
Democritus	8
Moreley	8
Nessler	8
Onnes	8
Siemens	8
Van Marum	8
Winkler	8
Aristotle	7
Betts	7
Dumas	7
Fischer, Emil	7
Harkins	7
Hückel	7
Linde	7
Meyer, Victor	7
Newton	7
Perkin	7
Schoenbein	7
Thomas	7
Vinci	7
Weston	7
Andrews	6
Bergius	6
Brandt	6
Carrel	6
Frankland	6
Hillebrand	6
Kirchoff	6
Martin	6
Mayow	6
Meker	6
Mond	6
Nobel	6
Ohm	6
Thénard	6
Valentine	6
Arfvedson	5
Brin	5
Clark	5
Coolidge	5
Drake	5
Fahrenheit	5
Frauenhofer	5
Geber	5
Gilchrist	5
Hare	5
Hofmann	5
Joule	5
Kelly	5
Landolt	5
Mohr	5
Nilson	5
Noyes	5
Paracelsus	5
Paraselsius	5
Sherman	5
Travers	5
Van Helmont	5
Werner	5
Wilson	5
Zsigmondy	5
Baeyer	4
Bancroft	4
Becker	4
Bergmann	4
Bernouilli	4
Boisbaudron	4
Bradley	4
Burton	4
Caro	4
Carter	4
Cronstedt	4
Downs	4
Frary	4
Frazier	4
Gahn	4
Goodyear	4
Hales	4
Hampson	4
Hess	4
Hevesy	4
Hopkins	4
Kelvin	4
Klaproth	4
Kossel	4
Lovejoy	4
Noddack	4
Oersted	4
Pasteur	4
Pattinson	4
Perrin	4
Planck	4
Silliman	4
Siedentoff	4
Torricelli	4
Urey	4
Vauquelin	4
Watt	4
Allison	3
Ampère	3
Boltwood	3
Bosch	3
Cady	3
Clausius	3
Condy	3
Coster	3
Cruikshank	3
Daguerre	3
Debierne	3
Einstein	3
Frank	3
Galileo	3
Gladstone	3
Hermanns	3
Hertz	3
Homer	3
Hooke	3
Hopkins	3
Keesom	3
Kellner	3
Knietsch	3
Lunge	3
McCoy	3
Maxwell	3
Mitscherlick	3
Morse	3
Murdock	3
Murphy	3
Nernst	3
Owens	3
Pfeffer	3
Plato	3
Pliny	3
Remsen	3
Rey	3
Schoop	3
Serpek	3
Stoney	3
Stromeyer	3
Taylor	3
Thomsen	3
Van der Waal	3
Vorce	3
Woodhouse	3
Agricola	2
Anaxagoras	2
Anaximenes	2
Bacon	2
Baekeland	2
Bayen	2
Becker	2
Beckmann	2
Blagden	2
Bonhoeffer	2
Boussingault	2
Brickwidde	2
Brønsted	2
Brownrigg	2
Bussy	2
Carlisle	2
Chardonnet	2
Compton	2
Cort	2
Coulomb	2
Curie, Marie	2
deChancourtois	2
Dioscorides	2
Dorn	2
Drummond	2
Empedocles	2
Findlay	2
Fischer, Hans	2
Fowler	2
Franklin	2
Freundlich	2
Gibbs	2
Goldstein	2
Heisenberg	2
Hisinger	2
Hittorf	2
Holmes	2
Hooker	2
Humboldt	2
Hyatt	2
Javelle	2
Kekulé	2
Kendall	2
Kjeldahl	2
Kunkel	2
Lamy	2
Laplace	2
Lechanché	2
Leucippus	2
Mariotte	2
Matthiessen	2
Millon	2
Moore	2
Mosander	2
Musket	2
Nielson	2
Nicholson	2
Osborne	2
Parson	2
Pauling	2
Phillips	2
Plucker	2
Regnault	2
Reich	2
Reichenstein	2
Richter	2
Rickets	2
Roscoe	2
Sabatier	2
Smeaton	2
Smith	2
Soret	2
Svedberg	2
Thales	2
Thompson	2
Townsend	2
Volta	2
Walker	2
Washburn	2
Watson	2
Weldon	2
Whitney	2
Wollaston	2
Wroblevski	2
Acker	1
Adams	1
Aitken	1
Ängstrom	1
Apdin	1
Atwater	1
Babcock	1
Baekeland	1
Balmer	1
Barlow	1
Bartow	1
Baxter	1
Beams	1
Beddoes	1
Beecher	1
Benedict	1
Berg	1
Berjerinck	1
Berkeley	1
Berkefeld	1
Berl	1
Berry	1
Bevan	1
Beyerinck	1
Boltger	1
Booth	1
Bothe	1
Bracket	1
Braham	1
Braun	1
Brownlee	1
Brühl	1
Bruyn	1
Bucher	1
Büchner	1
Burchard	1
Burgess	1
Burrell	1
Byrd	1
Cadet	1
Cailletet	1
Cameron	1
Carius	1
Carothers	1
Carr	1
Cascciorolo	1
Casole	1
Celsius	1
Chadwick	1
Chamberlain	1
Chance	1
Chancel	1
Chapin	1
Chevreul	1
Chrysoberyl	1
Claus	1
Clement	1
Cleve	1
Cockroft	1
Colburn	1
Cook	1
Coopier	1
Cordus	1
Costa	1
Courtines	1
Cowles	1
Crawford	1
Crocker	1
Cross	1
Curtius	1
Cushman	1
Dampier	1
Darrow	1
Darwin	1
Davisson	1
Debierne	1
De Broglie	1
d'Elhujar	1
De Graaff	1
De Haas	1
Delafontaine	1
Del Rio	1
Dennis	1
de Saussure	1
Desormes	1
Despretz	1
Deville	1
Diesel	1
Dirac	1
Divers	1
Duane	1
Duckworth	1
Duclaux	1
Dyar	1
Edgerton	1
Elsholz	1
Emmens	1
Epicurus	1
Epson	1
Ercker	1
Erdmann	1
Evans, M. A.	1
Evans, U. R.	1
Fajans	1
Falk	1
Fauser	1
Fawcault	1
Fievie	1
Fink	1
Fizeau	1
Foster	1
Fresnel	1
Friedländer	1
Gadolin	1
Gaillard	1
Gans	1
Gassner	1
Gautier	1
Gerhardt	1
Germer	1
Gersdorffite	1
Glosvenor	1
Gomberg	1
Gore	1
Graebe	1
Gray	1
Grew	1
Grignard	1
Grillo	1
Grosse	1
Grotthus	1
Harden	1
Hardy	1
Harley	1
Harrington	1
Hartlet	1
Hatchett	1
Helmont	1
Hemming	1
Henckel	1
Heraklitus	1
Herschel	1
Hershey	1
Hesiod	1
Heuckel	1
Higgins	1
Hinricks	1
Hisinger	1
Hittorf	1
Hjélm	1
Holes	1
Honigschmid	1
Hubbard	1
Hull	1
Humpridge	1
Huyghens	1
Ingenhousz	1
Jaeniche	1
Jeans	1
Joffe	1
Joliot, F.	1
Joliot, Irene	1
Jorgensen	1
Joss	1
Kahlenberg	1
Kanada	1
Kayser	1
Keijes	1
Killeffer	1
Kingzett	1
Koppers	1
Kovarik	1
Kraft	1
Kreuznach	1
Kronig	1
Kunitz	1
Ladenburg	1
La Mer	1
Larson	1
Laurent	1
Lawrence	1
Le Bel	1
Lecoq de Boisbaudron	1
Lee	1
Lenard	1
Lenssin	1
Leverrien	1
L'Hermite	1
Liebermann	1
Lippman	1
Little	1
Lomonossov	1
Long	1

TABLE 3 (*Continued*)

Name	No. of Books	Name	No. of Books	Name	No. of Books
Lorentz	1	Pauli	1	Stevens	1
Lossen	1	Peligot	1	Stieglitz	1
Lothar	1	Petri	1	Stockbridge	1
Lowry	1	Pickering	1	Stohmann	1
Luckhardt	1	Pictet	1	Strauss	1
Lucretius	1	Pope	1	Strutt	1
Lyman	1	Porter	1	Sutherland	1
Mac Afee	1	Pott	1	Tacke	1
McBride	1	Pregl	1	Talbot	1
McClendon	1	Price	1	Tennant	1
McCollum	1	Raman	1	Theophratus	1
McFarland	1	Raschig	1	Thilosier	1
McLennan	1	Reaiemer	1	Thomson, G. P.	1
Macquer	1	Reese	1	Thoulit	1
Magnus	1	Reinsch	1	Tocke	1
Mallet	1	Rinman	1	Tolman	1
Manley	1	Risteen	1	Treat	1
Margraaf	1	Roebuck	1	Turquet	1
Marignac	1	Roemer	1	Twitchell	1
Mathers	1	Röntgen	1	Urbain	1
Mendel	1	Roozeboom	1	Van den Brock	1
Mercer	1	Rowland	1	VanHelmholtz	1
Metchnikoff	1	Rumford	1	Villiger	1
Michelson	1	Runge	1	Von Euler	1
Miethe	1	Rydberg	1	Von Helmholtz	1
Miller	1	Sale	1	Von Weimarn	1
Millon	1	Scheibler	1	Wachenroder	1
Mills	1	Schenck	1	Wadmore	1
Mitchell	1	Scherrer	1	Wainer	1
Mittasch	1	Schiff	1	Waksman	1
Montgolfier	1	Schneitzer	1	Wallach	1
Morveau	1	Schönhers	1	Walton	1
Moureu	1	Schönkin	1	Wanklyn	1
Müller	1	Schrödinger	1	Waterston	1
Muntz	1	Schrötter	1	Wieland	1
Newman	1	Schulze	1	Wiener	1
Nicholsen	1	Sefstrom	1	Weintraub	1
Northmore	1	Selwood	1	Whipple	1
Northrup	1	Setterberg	1	Whitham	1
Odling	1	Seubert	1	Whiting	1
Okzewski	1	Shields	1	Wihelmy	1
Olszewski	1	Simons	1	Williamson	1
Orford	1	Slater	1	Willson	1
Palan	1	Slosson	1	Willstätter	1
Papish	1	Smith, E. F.	1	Windaus	1
Park	1	Socks	1	Withering	1
Parr	1	Sonnenschein	1	Wood	1
Paschen	1	Sorel	1	Woulfe	1
Patrick	1	Sørensen	1	Wright	1
		Splodowski	1	Young	1

Certain findings resulting from this and the previous study[1] are worthy of consideration and comparison. These can best be presented in tabulated form and are included in Table 4.

CONCLUSIONS

In addition to the facts which are immediately obvious from a study of Tables 1 to 4, the following conclusions seem to be justified on the basis of this study.

1. There is an extremely wide variation in the type and amount of historical material in representative college general chemistry textbooks.

2. Many of these texts do not utilize to the best advantage the opportunities for the historical approach to important topics, laws, and theories.

3. In several cases, numerous names and events are merely mentioned without any consistent continuity or development of the historical approach.

4. The use of portraits and historical cuts is generally recognized as an essential, or at least desirable feature of college general chemistry textbooks.

5. In many instances there is a tendency to elaborate spectacular rather than fundamental developments in the history of chemistry.

6. The amount of historical material in the college textbooks is generally much greater than in the high-school books.

7. The high-school texts are inclined toward a greater use of biographical material and portraits than the college texts.

8. There is a striking correlation between individual names of chemists who head the college and high-school lists in order of frequency. All names, except five that appear ten or more times on the high-school list, also appear an equal number of times on the college list.

TABLE 4

COMPARISON OF HISTORICAL MATERIALS IN HIGH-SCHOOL AND COLLEGE CHEMISTRY TEXTBOOKS

	20 High-school Texts	*20 College Texts*
Total number of texts included in study	20	20
Maximum words in historical accounts	4,030	26,773
Minimum words in historical accounts	132	920
Total words in historical accounts	34,378	155,134
Average words in historical accounts	1,719	7,757
Average words in historical accounts of 10 texts prior to January 1, 1931	1,147	9,040
Average words in historical accounts of 10 texts after January 1, 1931	2,070	6,473
Total number of names in 20 texts	1,436	2,516
Names appearing 20 times	4	4
Names appearing 19 times	5	8
Names appearing 18 times	2	7
Names appearing 17 times	3	8
Names appearing 16 times	5	8
Names appearing 15 times	5	9
Names appearing 14 times	2	7
Names appearing 13 times	3	9
Names appearing 12 times	10	5
Names appearing 11 times	5	8
Names appearing 10 times	2	4
Names appearing 9 times	10	14
Names appearing 8 times	8	12
Names appearing 7 times	11	14
Names appearing 6 times	3	15
Names appearing 5 times	9	25
Names appearing 4 times	12	37
Names appearing 3 times	34	46
Names appearing 2 times	36	84
Names appearing 1 time	166	342
Total names, minus duplications	336	666
Total biographical accounts	247	83
Range of biographical accounts	0 to 31	0 to 29
Total biographical accounts, minus duplications	48	46
Total portraits in twenty texts	253	170
Range of portraits in twenty texts	0 to 30	0 to 29
Total portraits in twenty texts, minus duplications	48	65
Total historical cuts in twenty texts	48	65
Inclusion of discovery of radium	13	17
Inclusion of discovery of oxygen	14	18
Inclusion of history of periodic table	11	18
Inclusion of discovery of argon	10	19
Inclusion of discovery of helium	7	20

There cannot be any issue between faith and science, for science and faith mutually exclude one another; not in the sense that the one renders the other impossible, or vice versa, but rather that so far as science extends faith does not exist, and faith begins where science leaves off. It cannot be denied that beyond this limit there may be real objects to be embraced by faith. It is, therefore, not the object of science to destroy faith, but rather to define the boundaries to which knowledge extends, and within these to establish a uniform system.—RUDOLF VIRCHOW

SOME SIMPLE EXPERIMENTS DEALING *with* RATES *of* SOLUTION

GEORGE W. GLEESON

Oregon State College, Corvallis, Oregon

THE purpose of the following is to describe briefly two simple, inexpensive, laboratory procedures dealing with the rate of solution of common salt. The significance of the experimental data can be obtained elsewhere (*1, 2, 3*) and any discussion of the development of theory beyond that necessary for elemental treatment is omitted from this writing. It is considered that the experiments contain all of the essential elements desired in elementary laboratory instruction; namely, the procedures can be completed in less than three hours; the equipment and supplies are relatively inexpensive; no particular manipulative skill is necessary, and adequate treatment of the data in the form of a report or write-up calls for ingenuity and the application of some mathematical procedures. The last-mentioned element is too frequently omitted from the "cook book" type of experiment. Furthermore, the simplicity of the manipulation and the rather far-reaching significance of the results are generally a surprise to students.

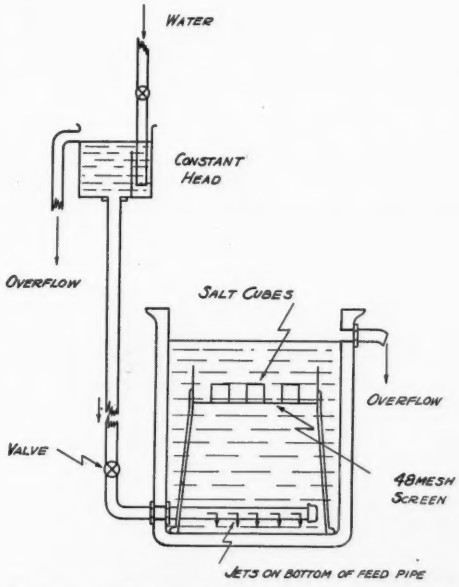


FIGURE 1.—ARRANGEMENT OF APPARATUS FOR FIRST ORDER PROCESS

According to the Berthoud-Valeton Theory (*4*), the rate of solution of a crystalline substance depends upon rate of diffusion and a first order surface reaction. This fact can be most simply expressed as,

$$\frac{dW}{d\theta} = KS(C_s - C_\theta) \qquad (1)$$

Where W is the weight of undissolved solute
θ is the time
S is the surface area of the undissolved solute
C_s is the concentration of solute in solution at saturation
C_θ is the concentration of solute in solution at time θ
K is a constant

Equation 1 is for a second order process; however, by maintaining negligible concentration of solute in the solution, the diffusional resistance drops out and a first order process results wherein the rate of solution depends only upon the surface area of undissolved solute. Figure 1 shows the simple arrangement of apparatus for study of the first order process. A constant head is maintained by an overflow weir which is supported by a ring stand. The container is a common crock with bottom opening and overflow, in which a laboratory tripod supports a 48-mesh screen. The solvent (water) flows past the salt cubes on the screen at a rate such that salt accumulation in the water is negligible. The ordinary tap water supply is usually of a uniformity of temperature sufficient to maintain essentially isothermal conditions.

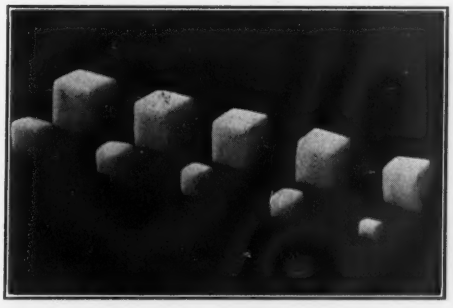


FIGURE 2.—SALT CUBES AFTER VARIOUS PERIODS OF SOLUTION

The salt cubes are prepared by sawing one-inch cubes from a block of ordinary stock salt. With reasonable care, perfect cubes can be prepared. Six or more of these cubes are weighed and measured, and arranged on the screen in known order. The screen and contents are submerged and the time taken. At the end

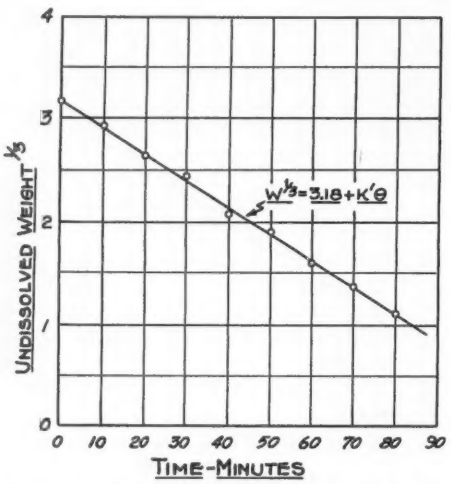


FIGURE 3.—RESULTS OF MEASUREMENT OF RATE OF SOLUTION BY THE FIRST ORDER PROCESS

of every ten-minute period, one cube is removed from the solution, roughly dried with paper toweling, and placed in a drying oven. Every time a cube is removed, the remaining cubes are rotated to rest on a new face, thus maintaining the approximate cubical shape by distribution of "stream lining." After all cubes have been removed and dried, they are again weighed and measured. (Drying at 110°C. for forty minutes is sufficient.) Figure 2 illustrates the condition of ten cubes after solution as described above for periods of from ten to one hundred minutes.

Returning to a consideration of equation 1, elimination of the concentration terms gives,

$$\frac{dW}{d\theta} = KS \qquad (2)$$

Since, for geometrical solids, the surface area is proportional to the weight to the two-thirds power (proof of this fact is left to the student) we may express equation 2 as,

$$\frac{dW}{W^{2/3}} = K'd\theta \qquad (3)$$

Integration of equation 3 gives,

$$3W^{1/3} = K'\theta + C \qquad (4)$$

where C is the constant of integration which may be obtained by substituting the weight of cube number one at O time.

Equation 4 indicates that a plot of $W^{1/3}$ versus θ should yield a straight line on ordinary coördinates with an intercept at $\theta = O$ of $C/3$ and a slope of $K'/3$. Verification of this fact and a comparison of previously calculated results with the experimental results are the subject of discussion required in the student report. Table 1 and Figure 3 are included to illustrate the results which may be obtained by following the procedures described.

Figure 4 illustrates the laboratory apparatus necessary when the second order process controls. A two-

TABLE 1

EXPERIMENTAL RESULTS FROM FIRST ORDER PROCESS

Time—θ minutes	*Weight—W grams*	*Weight—$W^{1/3}$ grams*
0	32.0	3.18
10	25.1	2.93
20	18.2	2.63
30	14.5	2.44
40	8.8	2.07
50	7.0	1.91
60	4.03	1.59
70	2.58	1.37
80	1.35	1.11

In equation $3W^{1/3} = K'\theta + C$, for $\theta = 0$, $C = 3(32)^{1/3} = 9.54$ so the equation simplifies to $W^{1/3} = 3.18 + K''\theta$.

liter beaker contains the solvent, and a $1^1/_2$- to 2-inch salt cube as cut from a block of stock salt is the solute. The larger the salt cube in comparison to the amount

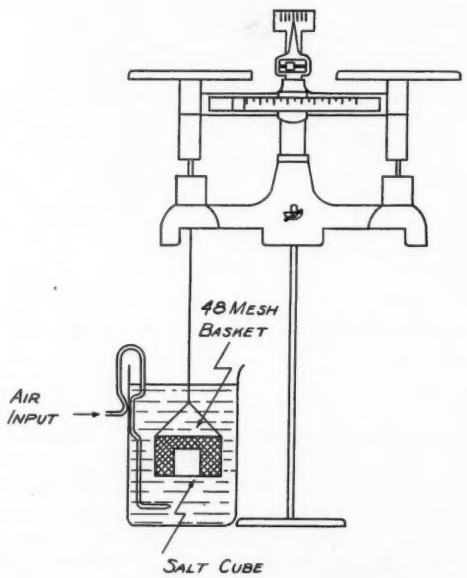


FIGURE 4.—ARRANGEMENT OF APPARATUS FOR SECOND ORDER PROCESS

of solvent, the more definite will be the evidence of the effect of concentration upon the solution rate. Air agitation has been used in the past, but more satis-

factory results are obtained by mechanical agitation, since the air bubbles tend to cling to the basket. The procedure is to obtain the basket weight submerged, the weight and measurements of the salt cube and, finally, the weight of the basket plus salt cube submerged at zero time. The agitation is maintained at a uniform rate and interrupted every five minutes in order to obtain the submerged weight of cube plus basket.

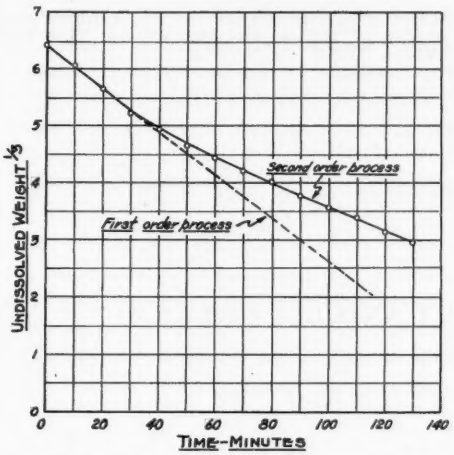


FIGURE 5.—RESULTS OF MEASUREMENT OF RATE OF SOLUTION BY SECOND ORDER PROCESS SHOWING DEVIATION FROM FIRST ORDER PLOT

The weighing procedure is repeated at five-minute intervals until sufficient data are available.

Equation 1 is applicable for the second order process. C_s is, of course, a constant as obtained from solubility tables, but C_θ is a variable quantity and is evaluated as,

$$C_\theta = W_0 - W$$

Where W_0 is the weight of the cube (unsubmerged) at O time.

W is the weight of the cube (unsubmerged) at any time. Substitution of $W_0 - W$ for C_θ and $W^{2/3}$ for S gives

$$\frac{dW}{d\theta} = K'W^{2/3}(C_s - W_0 + W) \qquad (5)$$

$C_s - W_0$ is a constant which can be designated by C_0. Substituting this value and rearranging for integration between limits gives,

$$\int_{W_0}^{W} \frac{dW}{W^{2/3}(C_0 - W)} = K' \int_{dO}^{\theta} \qquad (6)$$

The left-hand side of equation 6 presents some difficulties; consequently, students are advised to integrate graphically by plotting

$$\frac{1}{W^{2/3}(C_0 - W)} \text{ versus } \theta$$

The area under the curve (obtained by square counting, with a planimeter, or by weighing cut sections on a balance) gives the value of the left-hand side of the equation, and these values are plotted versus θ. Equation 6 indicates that the latter plot should be a straight line passing through the origin and having a slope of K'. Furthermore, if a plot of $W^{1/3}$ *versus* θ is constructed, inspection will show that the second order process approximates the first order process at the start when the concentration of salt in solution is small, and that the deviation from the first order process increases as the concentration gradient is diminished by the increase in concentration.

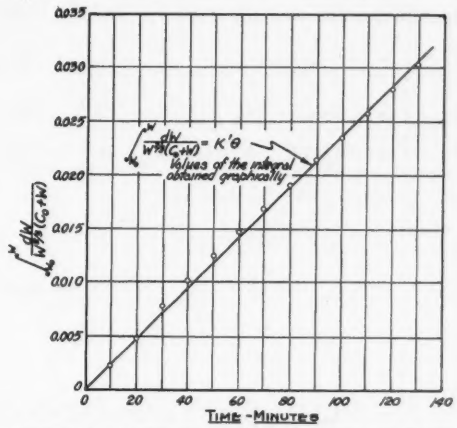


FIGURE 6.—RESULTS OF MEASUREMENT OF RATE OF SOLUTION BY SECOND ORDER PROCESS

Table 2 and Figures 5 and 6 are included to indicate the results that are obtained in class work according to the procedures described. It would probably be somewhat misleading not to call attention to the fact that as the concentration of the solution increases in the second order process, the buoyant effect on the cube

TABLE 2

EXPERIMENTAL RESULTS FROM SECOND ORDER PROCESS

Time —θ	Weight of cube—g.			Weight $W^{2/3}$—	1*	
	Sub-merged	Un-dissolved	Dis-solved	g.	$\frac{1}{W^{2/3}(C_0-W)}$	$\int_{W_0}^{W} \frac{dW^*}{W^{2/3}(C_0-W)}$
minutes						
0	127.7	267.5	0	41.7	0.0470	0
10	106.3	222.0	45.5	36.8	0.0585	2.22
20	85.8	180.0	87.0	32.0	0.0735	4.80
30	59.4	144.8	122.7	27.6	0.0938	7.75
40	58.2	122.0	145.0	24.6	0.112	10.10
50	49.1	102.6	164.9	21.9	0.133	12.52
60	41.8	87.4	180.1	19.7	0.154	14.7
70	36.0	75.0	192.5	17.8	0.177	16.8
80	30.7	64.0	203.5	16.0	0.204	19.0
90	25.7	53.3	214.2	14.2	0.238	21.3
100	21.2	44.3	223.2	12.5	0.278	23.4
110	17.8	37.2	230.3	11.2	0.318	25.6
120	14.8	31.0	236.5	9.85	0.372	28.0
130	12.2	25.4	242.1	8.65	0.431	30.2

* Values $\times 10^3$.

and basket is greater and the recorded loss in weight is due to the sum of the loss of weight of cube plus decrease in weight due to increased buoyant effect. Applying suitable corrections presents the student with a difficulty that requires some thought to master.

In conclusion, the writer believes the experiments as described offer an opportunity for mathematical interpretation of results, information of real significance, and training in analyzing experimental data, that are seldom encountered using such inexpensive equipment and requiring such elemental laboratory technic. Furthermore, the students exhibit a lively interest in an experiment which combines the several elements of their training.

LITERATURE CITED

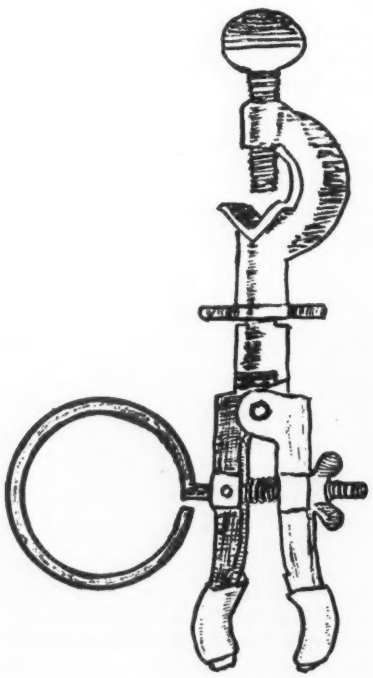
(1) HIXSON AND CROWELL, *Ind. Eng. Chem.*, **23**, 923, 1002, 1160 (1931).
(2) HIXSON AND TENNEY, *Proc. A. I. Ch. E.*, **31**, 173 (1934).
(3) HIXSON AND WILKENS, *Ind. Eng. Chem.*, **25**, 1196 (1933).
(4) *J. Chem., Phys.*, **10**, 625 (1912). See "Chemical engineers' handbook," McGraw-Hill Book Co., Inc., New York City, **1934**, p. 1474.

COMBINATION FUNNEL SUPPORT AND BURET CLAMP

PHILIP S. CHEN

Nashville Agricultural Normal Institute, Madison College, Tennessee

THE ordinary wooden funnel support used in most chemical laboratories is quite bulky, and unlike some of the other pieces of laboratory apparatus, it serves but a single purpose. It occupies too much room on the table when in use, and takes up a large portion of drawer space when stored away. For these reasons, its use in the chemical laboratory is more or less limited to quantitative analysis work, which calls for frequent filtration operations, in each operation three or four funnels being employed simultaneously. For general chemistry laboratory work, which seldom calls for this operation and where one set of filtration is usually sufficient, the use of the ordinary bulky wooden funnel support is quite inconvenient. Consequently, instead of using the funnel support, the student generally resorts to the use of either iron rings or buret clamps. The use of the iron ring as a substitute is limited to large-size funnels only. For the ordinary size funnel, the iron ring is too large. On the other hand, the use of the buret clamp does not give satisfactory results. Since it has a loose grip on the funnel stem, which is often too slender, it does not give a steady, rigid support to the funnel, and spilling of the solution from the funnel is frequently the result.



Fortunately, this situation can be easily eliminated by a simple alteration in the construction of the buret clamp. By replacing the hand screw on the clamp with one that has a ring on the end, as shown in the figure, the buret clamp can be made to serve the additional purpose of a funnel support. The size of ring may be varied, but one of one and one-half inches in diameter is large enough for the ordinary 65-mm. funnel. The improved hand screw may be fastened to the clamp by riveting both the screw and clamp together. The funnel ring then becomes stationary.

A LABORATORY THERMOREGULATOR

HOWARD M. WADDLE AND ROBERT E. IMHOFF*

Georgia School of Technology, Atlanta, Georgia

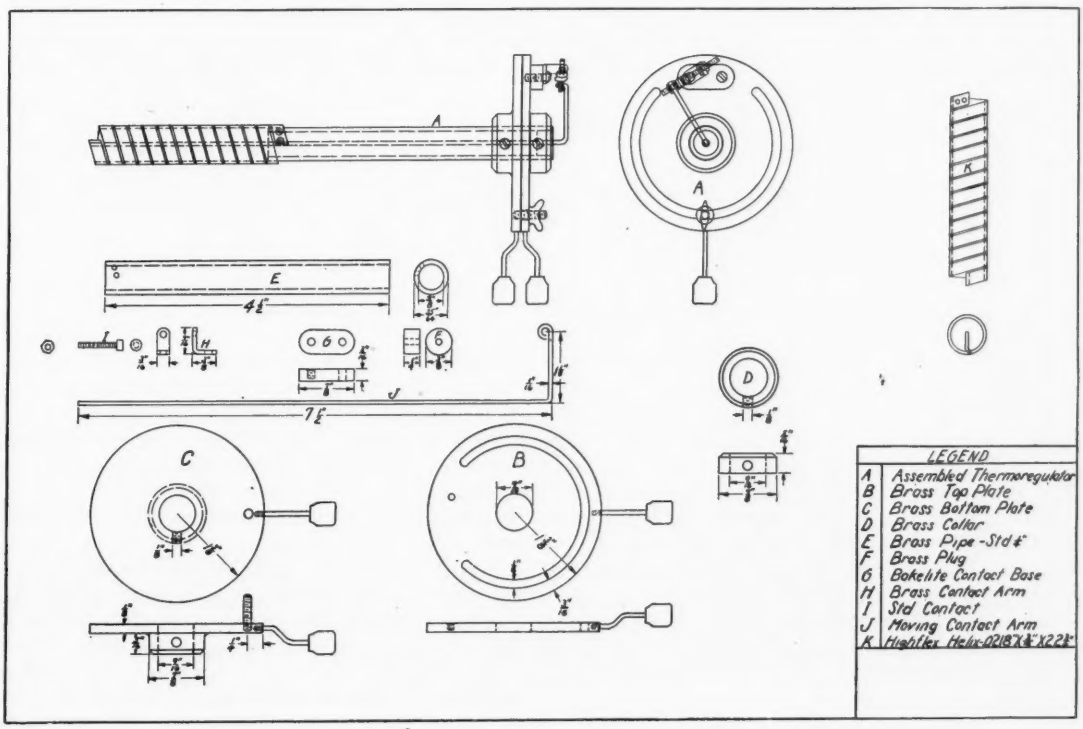
A THERMOREGULATOR capable of extensive use in the laboratory is herein described. The main advantages of this thermoregulator over the conventional mercury type are that it is rugged, can be used over a wide range of temperature, and is capable of maintaining a constant temperature at any of the temperatures. The problem of securing positive electrical contacts is reduced to a minimum. The thermoregulator can be used in any position. The author has used this thermoregulator to control the temperature of oil baths in distillations during which it was necessary to vary the temperature of the oil bath from 50°C. to 225°C. at 5° intervals. This thermoregulator uses the same basic principle as the de Khotinsky regulator[1] which was later improved by P. E. Klopsteg and W. H. Stannard,[2] that is, the coiling and uncoiling of a bimetal helix with a decrease and increase in temperature. The main feature of distinction is its simplicity, ease of construction and low cost. The author feels that it will prove very satisfactory to the user where temperature control of ± 0.3°C. is sufficient.

The construction of the thermoregulator is apparent from the drawing. Plate *B*, upon which the contact base, *G*, and contact arm, *H*, are placed, rotates with respect to plate *C*. Plate *C* is attached to the brass pipe, *E*, by means of a set screw. Plates *B*, and *C*, are brass and can be cast in a foundry and subsequently turned down in a lathe. If this is done the cost of parts for the entire thermoregulator should not exceed

* Present address: 7519 Wade Park, Cleveland, Ohio.

[1] DE KHOTINSKY, A., *U. S. Pat.* 1,375,780.

[2] KLOPSTEG, P. E. AND W. H. STANNARD, *U. S. Pat.* 1,629,710; *J. Optical Soc. Am.*, **7**, 179–86 (1923).



LABORATORY THERMOREGULATOR

seventy-five cents. A convenient method of clamping the thermoregulator to laboratory stands is to thread an eighth-inch hole in the shoulder of plate *C*, opposite the set screw, and place therein a suitable threaded brass rod of from eight to ten inches in length. The bimetallic helix used gave a rotation of 1° for each degree rise on the Fahrenheit scale. This helix can be purchased from companies dealing in bimetal.*

The thermoregulator should be used in connection with a suitable relay that operates on a small current, yet is capable of making and breaking the heating load. Such relays can be purchased from local dealers or made from materials readily available.[3] Electrical contacts are made by attaching one flexible insulated cable to the fixed contact on plate *B*, the other contact being made at any convenient place on the thermoregulator. The author uses the long rod which serves as a means of clamping the thermoregulator to the stands for this purpose. Since there is slight movement in the contact arm for a small rise in temperature, there is a tendency for arcing across the contact points, even though the sparking is reduced by means of suitable condensers. As a result of this arcing the contacts become slightly burned; and hence greater pressure between contacts is necessary in order to make sufficient connection to operate the relay. This decreases the sensitivity of the regulator. The author uses a modified form of the Universal A.C.-D.C. Thermionic Relay described by Hershberg and Huntress.[4] A 100-ohm resistance across the filament of the 71A tube is used to decrease the possibility of burning out the tube when the relay breaks a large load, thus causing an increased voltage. In this set-up only extremely minute current passes across the contacts.

In order to set the thermoregulator to operate at a definite temperature, the bath is brought up to that temperature, the fixed contact on the arm *H* is so adjusted that it just does not make contact with the contact on the moving contact arm *J*. This is done by rotating plate *B* with respect to plate *C*. Obviously, the range of the thermoregulator is not the range of the slot in plate *B*. The entire assembly, consisting of parts *E*, *K*, and *J* can be rotated with respect to the two plates. Thus a wide range is possible. In actual practice there is a slight elongation of the helix. This is of no consequence, for in extreme cases of elongation both plates *B*, and *C*, can be set closer to the helix *K*.

* Helixes used in this work were furnished by the H. A. Wilson Company, 105 Chestnut St., Newark, N. J., No. 1461 (F) Highflex 45.

[3] BLACK, P. T., *Science*, **79**, 322(1934).

[4] HERSHBERG, E. B. AND E. H. HUNTRESS, *Ind. Eng. Chem., Anal. Ed.*, **5**, 344–6 (1933).

A SIMPLE METHOD *of* CRYSTAL MODEL CONSTRUCTION

KEITH M. SEYMOUR*

Reed College, Portland, Oregon

AT LEAST an elementary knowledge of crystal structure is becoming increasingly more important to the chemist. The authors of general chemistry texts have recognized this fact, and most of the newer books in the field devote considerable attention to the subject. Physical chemistry texts are also giving more space to this material. However, the implications of crystal chemistry (*1*, *2*, *3*, *4*) are becoming so significant in so many fields that it seems imperative that a place is found in the curriculum for a somewhat more complete study of this subject than is feasible in either the beginning or the physical chemistry course. In an attempt to meet this need an experimental seminar course in crystal chemistry has been offered in this college to interested upper-division students for the past two years.

When introducing students to the subject of crystal chemistry it is desirable to have models of at least a few of the more common types of crystals which the student can handle and examine. Concepts such as coördination number, close packing, polymorphism, layer lattices (see CdI_2, in the Figure), and interpenetrating lattices (see ZnS, zinc blende, and CaF_2, in the Figure) which are frequently very difficult for the beginning student to understand become clear when a model is used.

Such models can be obtained commercially for certain common crystals, but the number available is very limited and their cost is prohibitive for the small institution not specializing in crystal work. Furthermore from the educational viewpoint it is much more valuable to the students if they are able to construct some of these models themselves. In order for a method of crystal construction to be satisfactory for

* Present address: Northern Montana College, Havre, Montana.

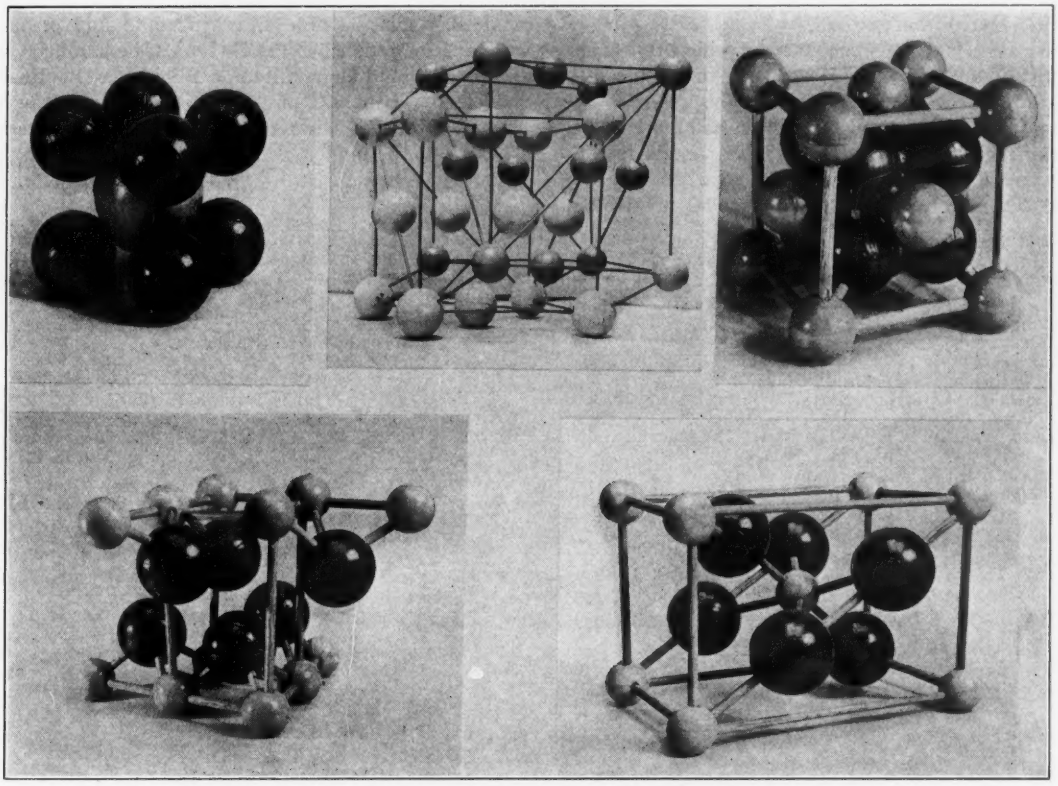
student use, it is important that it fulfills the following requirements.

1. The materials are cheap, easily accessible, and fairly easy to use.
2. The models produced are stable, attractive, and large enough that the relationships of the parts are easily seen.

Experiments were made with several different types of materials. For the atoms, or ions, such different materials as modeling clay, plaster of paris, sealing wax, wooden balls, and marbles* were tried or investigated. For the connecting rods wires of all kinds were investigated. The most satisfactory material of this type was a $^3/_{32}$-inch brass rod (see ZnS in the Figure) but the cost of the rod made it prohibitive for student use except for very simple models. Also this brass rod corroded rapidly in the laboratory atmosphere if not carefully lacquered. Monel metal rod was found which would be better, but it was still higher in price. It is suggested that such material might well be used for permanent models for a school collection.

The materials which were finally chosen as the most suitable were sponge rubber balls and $^1/_4$-inch oak doweling. The rubber balls were the lacquered, brightly colored (red blue, yellow, etc.) balls obtainable from ten-cent stores. If not available from this source, they could undoubtedly be obtained from toy wholesalers. Quite a variety of sizes is to be had.

Thus far only models for binary compounds have been prepared, but there is no reason why more complex crystals could not be constructed. The polarization of the ions was neglected. For more elaborate models it would be possible to deform these soft balls to approximate the effects of polarization if desired. However, some more rigid means of holding the balls in position would be needed.



LiCl ZnS (zincblende) CaF_2
CdI_2 TiO_2 (rutile)

When assigned the construction of a model for a given crystal, the student was expected to proceed as follows. First, he was to find the most reliable data for the dimensions of the unit cell of the crystal and of its constituents. The references given at the end of this paper were found the most useful for this purpose. Second, from the balls at hand those giving a radius ratio nearest the accepted value were chosen. It was

* Since this work was completed A. SCATTERGOOD (J. CHEM. EDUC., **14**, 140 (1937)) has described the preparation of simple models from marbles. These work very well for the construction of close-packing and other simple models but have obvious disadvantages for large or complex models.

usually found impossible to find two sizes of balls giving exactly the desired radius ratio, but extremely close values were obtained in most cases. The CaF_2 model was made from balls 3.1 and 4.2 cm., respectively, giving a radius ratio of 0.74, almost exactly the accepted value. Third, the proper dimensions, in centimeters, of the unit cell were calculated by proportion from the radius of the balls used and the radius of the atom or ion represented. In case there was a significant deviation from the true radius ratio the dimensions of the unit cell was taken as the mean of the respective values calculated from the two balls used. This method gave less distortion than the use of the value calculated from one ball.

A few models were constructed in which the dimensions of the unit cell were larger than those calculated from the sizes of the balls used. This made it possible to see the relationship within the cell more clearly. The unit cells for the TiO_2 and ZnS models (see the Figure) were made exactly twice the calculated size.

The actual construction of the model involved no particular technic. In using the doweling, it was found that an ordinary brass cork borer made the most suitable hole. Care must be taken to locate the holes properly, or the model will be distorted.

In conclusion, let us compare the results with the requirements we set up for a suitable method of construction. The materials are quite cheap. The balls cost from three-for-a-nickel to five cents each. The doweling was one cent a foot. Only the CaF_2 and the ZnS models cost more than fifty cents, and in the latter nearly half of the cost was for the rod. The materials are easily obtained, at least in a fairly large city, and are very easy to use. The more compact models are very stable and will stand any ordinary handling. Models like the CdI_2 must be handled carefully and should be mounted on a board. The finished models are attractive, and their bright colors draw the attention of other students and arouse their interest. The size of the models is convenient both for handling and for the demonstration of the relationships of the parts.

BIBLIOGRAPHY

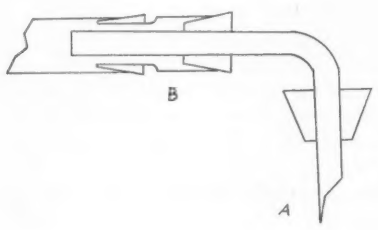
(1) STILLWELL, C. W., J. CHEM. EDUC., **10**, 590–9, 667–74 (1933).
(2) STILLWELL, C. W., *ibid.*, **13**, 415–9, 469–77, 521–25, 566–75 (1936); *ibid.*, **14**, 34–43, 131–8 (1937).
(3) HASSEL, O., "Crystal chemistry," William Heinemann, Ltd., London, **1935**, 94 pp.
(4) BRAGG, W. L., "The crystalline state," The Macmillan Company, New York City, Vol. 1, **1934**, 353 pp.
(5) WYCKOFF, R. W. G., "Structure of crystals," 2nd edition, Reinhold Publishing Corp., New York City, **1931**, 497 pp.
(6) WYCKOFF, R. W. G., "Structure of crystals," Supplement, 1930–1934, Reinhold Publishing Corp., New York City, **1935**, 256 pp.
(7) VON LAUE, M. AND R. VON MISES, "Stereokopbilder von Kristallgittern," Julius Springer, Berlin, Vol. 1, **1926**, 43 pp.
(8) VON LAUE, M. AND R. VON MISES, "Stereokopbilder von Kristallgittern," Julius Springer, Berlin, Vol. 2, **1936**, 56 pp.

AIDS TO VACUUM DISTILLATION

THOS. S. GARDNER

Kingsport, Tennessee

THE efficiency of a vacuum distillation can be increased by fusing a sliver of glass on to the goose-neck after the cork has been put on. Drops of liquid that would be entrained have their film broken and thus flow down the sliver into the distilling flask. The sliver of glass may be renewed every time the cork is changed. (See *A* in the figure.)



In a vacuum distillation, wherein it is necessary to use cork instead of rubber stoppers, condensers are often broken in removing the seal of shellac, dope, water glass, or other types of seals. For a series of distillations using the same apparatus it is more convenient to form a permanent seal as shown in *B* by using an inner jacket. Therefore, if the jacket is broken while removing the cork on the goose-neck leading to the condenser, the condenser may be saved by dissolving off the permanent seal in a suitable solvent.

WILLIAM O. BROOKS
A. T. BURTSELL
R. K. CARLETON
TENNEY L. DAVIS
C. K. DEISCHER
J. HOWARD GRAHAM
B. CLIFFORD HENDRICKS

ABSTRACTS

J. W. HOWARD
D. C. LICHTENWALNER
GRETA OPPE

C. M. PRUITT
LEOPOLD SCHEFLAN
A. A. VERNON
E. D. WALTER
MARY ELVIRA WEEKS
SIDNEY WEINHOUSE
G. H. WOOLLETT

KEEPING UP WITH CHEMISTRY

Negative catalysts. ANON. *Ind. Bull. of Arthur D. Little, Inc.*, **131,** 4 (Dec., 1937).—For years chemists have been using catalysts to speed up chemical actions, apparently ignoring the reasons why some chemical changes take place slowly, causing inconvenience and loss as corrosion of metals, aging of rubber, and rancidity of edible fats. The recent publication of Bailey's "The Retardation of Chemical Reactions" focuses attention upon negative catalysts or chemical inhibitors or anti-oxidants as they are sometimes called. Most present-day gasoline contains unsaturated compounds with excellent anti-knock characteristics, but unfortunately they tend to produce gum, which sticks valves and clogs carburetor orifices. Inhibitors are used to prevent the gum-forming constituents from oxidizing, while still retaining high anti-knock value. Useful anti-oxidants have been developed for rubber and a number of corrosion catalysts are doing excellent work. Corrosion retarders have been used in the acid-cleaning of automobile cooling systems and in anti-freeze solutions and in metal pickling. A number of organic acids have shown promise in the prevention of rancidity in edible oils. Anti-oxidants have been tried in paints to reduce brittleness and cracking. Gas and dust explosions in mines and factories have been inhibited experimentally by the addition of inert dusts and gases to atmospheres. Stabilizers have been introduced into vitamin-bearing products and aldehyde constituents into perfumes. Negative catalysts are expected to play an increasingly important rôle in improving the quality and serviceability of many a product now in general use. G. O.

From southern pines. ANON. *Ind. Bull. of Arthur D. Little, Inc.*, **132,** 4 (Jan., 1938).—The naval stores industry, dating from Colonial times when pitch was in great demand for caulking ships, is about to get a boost by recent developments in the last three or four years which have produced practical methods for processing the crude oleo resin from which turpentine and rosin are readily produced. The Glidden Company now manufactures a product of this nature under various trade names such as "Nelio Resin," "Clean Pine Gum," and "Gum Thus." The United States Department of Agriculture in its Naval Stores Research Station at Olustee, Florida, has developed methods for producing oleo resin of the same general nature. G. O.

Modern applications of deposition. R. A. F. HAMMOND. *Sch. Sci. Rev.*, **19,** 202–11 (Dec., 1937).—The process of electroplating began industrially about a century ago, following the invention of the Daniell cell in 1836. From 1840 to 1870 copper, silver, and gold plating were the applications most in use, until 1869 the process of nickel plating was patented by Adams. The next important development was that of chromium plating in 1920.

Chromium possesses the advantage among base metals of retaining a brilliant luster for long periods, due to the self-repairing passive film which is normally present on the surface. Chromium deposits are unsuitable for use alone, however, on account of the pores and cracks which they contain, through which corrosion of the basis-metal would occur, causing rapid deterioration of the finish. It is therefore customary to apply an undercoat of nickel, which may be deposited in a relatively non-porous condition.

Zinc and cadmium are especially valuable coatings for steel, since they provide marked electrochemical protection which is not dependant on freedom from porosity in the deposit. Among the applications in current use are the plating of telephone and radio equipment. S. W.

Laboratory cements and waxes. L. WALDEN. *Sch. Sci. Rev.*, **19,** 212–27 (Dec., 1937).—Formulas and directions are given for the preparation of numerous cements and waxes, such as sealing wax, shellac, etc., and a description of the physical properties and uses of various commercial products is included. S. W.

A homemade polarimeter for organic chemistry. G. F. HOOD. *Sch. Sci. Rev.*, **19,** 287–8 (Dec., 1937).—Description is given of a cheap, homemade polarimeter, using polaroid, polarizer, and analyzer. S. W.

Carotenoids of the chicken retina. G. WALD AND H. ZUSSMAN. *J. Biol. Chem.*, **122,** 449–60 (Jan., 1938).—Many bird and reptile retinas contain brightly pigmented oil globules situated in the position of light filters between the inner and the photosensitive outer limbs of the cones.

Extracts of chicken retinas were separated into a red acidic, a golden alcohol and a greenish yellow hydrocarbon fraction. From these, three carotenoids have been crystallized, possessing the properties of astacene, xanthophyll, and an unidentified hydrocarbon. It is concluded that astacene, and possibly the hydrocarbon, is synthesized by the chicken. The possible rôle of these pigments in color vision is discussed. E. D. W.

Biological value of the proteins of certain cereals. Z. MARKUZE. *Biochem. J.*, **31,** 1973–7 (Nov., 1937).—The biological values of the proteins of the most common Polish market cereals were determined by the method of Osborne *et al.* The highest value was found for buckwheat. The values diminished in the order fine buckwheat meal > whole buckwheat groats > rolled oats > barley meal > rice = semolina = whole wheat grain (hard or soft) > wheat flour > millet meal. E. D. W.

Aluminum soap. ANON. *Ind. Bull. of Arthur D. Little, Inc.*, **131,** 3 (Dec., 1937).—We are more or less familiar with soaps compounded from stearic acid and sodium and potassium; but there are also metallic soaps of calcium, magnesium, copper, and aluminum. Aluminum stearate is an increasingly popular product, being used in the formulation of solid lubricating greases from fluid oils, for it makes such oils jell. Textiles, leather, rope, and ceramic articles are often waterproofed with either calcium or aluminum stearate. Aluminum and zinc stearates are well known in paints and varnishes. Inks, rubber, plastics, crayons, and cosmetics are further outlets for metallic stearates. G. O.

Some chemical methods of weed destruction. H. C. LONG AND R. K. MACDOWALL. *J. Roy. Agr. Soc. of Eng.*, **96,** 22–44 (1935).—Work along this line up to 1934 is summarized in a previous publication, "The Birkins" by Long. The chief chemicals used are, H_2SO_4, Fe and Cu sulfates, $CaCN_2$, chlorates, and thiocyanates. H_2SO_4 is used extensively in spraying corn and potato crops for weed destruction. In France 500,000 acres of corn were treated in 1933. Used on potatoes the concentration is ten to twenty per cent., varying with weather conditions, the concentration being increased in wet weather. About one hundred gallons are used per acre. With bulb crops about eighty gallons per acre are used. In the last two years rainfall has been light, weeds less numerous and cyanimide, copper sulfate, and kainit have been used, being handled more easily. It is expected that H_2SO_4 will again be used when weather conditions are normal. H_2SO_4 spraying seems to be replacing $CuSO_4$, being more quickly effective and less affected by subsequent rains; it destroys more varieties of weeds, and produces no permanent injury to the crop.

Calcium cyanimide, in addition to its fertilizer value, is a weed killer. If the nitrogen addition is undesirable, H_2SO_4 should be used. It is applied as a fine powder, and a mixture of four parts fine kainit to one of cyanimide, using four cwt. per acre has been found effective. Used alone $1^1/_4$ cwt. per acre are satisfactory. Asparagus beds can be heavily dusted without injury to the plant,

but certain destruction of the weeds. In many cases the dose must be increased to six to ten cwt. for effective control.

Sodium chlorate is an effective weed killer at a concentration of ten to fifteen per cent., using one hundred gallons per acre. It should be used only on land not devoted to crops. Arable land if left vacant from four to six months, from autumn to early spring, can be treated with $1^1/_2$ to 2 cwt., applied as powder or solution. Tests in U. S. indicate that one hundred pounds of $NaClO_3$ per acre ceases to be toxic after one hundred thirty-one days, two hundred pounds after two hundred thirty-seven days, and four hundred pounds after a year. It is effective in killing dwarf thistle, nettles, hoary pepperwort, creeping thistle, bracken and others. The fire hazard of $NaClO_3$ must be considered.

Ammonium thiocyanate has a low period of sterility to crops sown after its use, being zero for one hundred pounds per acre, and with eight hundred pounds per acre, growth was stimulated after sixty-nine days. On first application it appears to be quite toxic to vegetation. The use of spraying machinery is also discussed. An extensive list of references is given. D. C. L.

APPARATUS, DEMONSTRATIONS, AND LABORATORY PRACTICE

Experimental explosions of coal gas, coal dust, and petrol vapor. W. RALSTON. *Sch. Sci. Rev.*, **19**, 173–81 (Dec., 1937).—Experiments are described for the controlled explosion of gasoline, coal gas, and coal dust. These require apparatus found in laboratories and can be carried out in perfect safety. A simple device for measuring the pressure produced in the explosion is also described. S. W.

HISTORICAL AND BIOGRAPHICAL

Bologna celebrates bicentenary of Galvani's birth. ANON. *Nature*, **140**, 836–8 (Nov. 13, 1937).—On October 17 to 20 the City and University of Bologna held a scientific congress in honor of Luigi Galvani. He was a lecturer in anatomy in the University of Bologna, where in 1791 he observed "the twitchings in the dissected muscles of a frog's leg whenever a spark was passed from a neighbouring electric machine to some other object, the only condition being that the animal should be in contact with some metal or other good conducting substance." The opening session of the congress was attended by the King and Queen of Italy and other government representatives. The commemorative address on the life and work of Galvani was delivered by Prof. Q. Marjorana. A library of Galvani memorabilia was formally opened. Addresses were delivered by Niels Bohr, E. D. Adrian, A. Gunsett, E. Fermi, G. von Hevesy, P. Debye, W. Bothe, W. Heisenberg, B. Rossi, F. W. Aston, M. L. E. Oliphant, and J. D. Cockcroft. M. E. W.

Anniversary meeting of the Royal Society. ANON. *Nature*, **140**, 979–81 (Dec. 4, 1937).—The presidential address on "The grain-like structure of solids" was delivered by Sir William Bragg. His Majesty, King George VI, expects to continue the gift of the two Royal Medals which have been awarded annually since 1825. The Copley Medal was presented to Sir Henry Dale, who isolated histamine and acetylcholine from animal tissues and discovered the part played by them in many physiological and pathological processes. From 1905 to 1911 he worked on the active principles of ergot.

A Royal Medal was awarded to Prof. N. V. Sidgwick, whose early work dealt chiefly with tautomerism and the vapor pressures, boiling points, and solubilities of isomerides. In his later work he has applied physical methods to the solution of special problems of structure. He showed the existence of the co-ordinated covalent link.

The Davy Medal was presented to Prof. Hans Fischer, who for twenty-five years has been investigating the porphyrins, the bile pigments, and chlorophyll. He synthesized protoporphyrin, "which, with iron, yielded haematin identical with that derivable from blood haemoglobin."

The Hughes Medal was presented to Prof. Ernest O. Lawrence of the University of California, inventor of the cyclotron, "the most important instrument of physical research since the C. T. R. Wilson expansion chamber, whereby ions are accelerated in a magnetic field and move within two half-cylinders which change electrical polarity in rhythm with the circulating ions, so that deuterons have been spirally speeded in a vacuum to velocities due to three million volts, and these deuterons, impinging on beryllium, have produced neutrons and protons in great number and some of the protons have been projected through the equivalent of forty centimeters of air . . . Such high-speed ions are available for developing the theory and practice of atomic disintegration, and Prof. Lawrence and his co-workers are playing a leading part in this development." M. E. W.

Francis P. Garvan. A. W. HIXSON. *Ind. Eng. Chem., News Ed.*, **15**, 539–40 (1937).—An account is given of the life of Francis P. Garvan who was born in 1875. He was graduated from Yale in 1897 and from New York Law School in 1899. Appointed to the staff of District Attorney's office of New York City in 1900, he became Alien Property Custodian in 1919. He founded the Chemical Foundation, Inc., and became its first president. A record is given of the many projects which were aided wholly or in part by the Chemical Foundation, Inc. A. A. V.

ADMINISTRATIVE PROBLEMS AND DEVICES; CURRICULA

Changing conceptions of teaching helps in general science textbooks. M. P. SIMMONS. *Sci. Educ.*, **20**, 211–14 (Dec., 1936).—An examination of the article indicates changes in number and types of teaching helps occuring in sixteen general science textbooks (1911–1934).

Four publishers were used for each of the four periods included in the twenty-four years of this investigation.

The findings reveal sixteen teaching helps: demonstrations, exercises, experiments, footnotes, glossaries, key statements, key words, pictures, projects, questions, references, reports, summaries, tables, tests, and topic surveys.

It is highly significant to note that such aids as exercises, experiments, and pictures receive a very high frequency. In contrast demonstrations, footnotes, glossaries, key statements, key words, reports, tests, and topic surveys reveal a very low count.

The highest frequency (13) for any book was one published in 1934. M. P. S.

Changing conceptions of major topics in general science textbooks (1911–1934). M. P. SIMMONS. *J. Educ. Research*, **31**, 199–204 (Nov., 1937).—An analysis was made of the word space devoted to major topics contained in sixteen (1911–1934) general science textbooks.

For ease of interpretation, the twenty-four years included in this study were divided into four periods with four publishers for each period.

The findings displayed by a graph indicate (1) sixteen major topics: air, animal life, electricity, energy, forces of nature, health, heat, light, machines, matter, planets, plant life, soils, sound, water, and weather; (2) a decided preference favoring the teaching of health, heat, machines, and water; (3) a decrease in emphasis among the topics: animal life, energy, forces of nature, matter, and sound; and (4) no definite trend in the increase of word space for any given topic. M. P. S.

Changing conceptions of topic illustrations in general science textbooks (1911–1934). M. P. SIMMONS. *J. Exper. Educ.*, **5**, 368–72 (June, 1937).—From sixteen general science textbooks investigated covering a period of years, 1911–1934, the author presents data relative to occurrence of pictures pertaining to the topic, air.

For ease of interpretation the twenty-four years included in this analysis were divided into four periods with four publishers for each period. Among the findings the following are highly significant.

1. Illustrations of the topic, air pressure, are predominant.
2. The remainder of the pictures pertaining to composition, oxidation, preparation of carbon dioxide, and preparation of oxygen showed a very low frequency.
3. It is interesting to note that one textbook (1911) lacked pictures entirely. M. P. S.

EDUCATIONAL MEASUREMENTS AND DATA

Student laboratory work versus teacher demonstration as a means of developing laboratory resourcefulness. P. GOLDSTEIN. *Sci. Educ.*, **21**, 185–93 (Nov., 1937).—This is the résumé of a study made to find out whether allowing students to do laboratory work is a better way for them to develop laboratory resourcefulness than is teacher demonstration of the same material. Two groups of girls, numbering twenty in each section, were equated. Ten tests were used. Results indicate that gaining experience by laboratory work seems to be a better way of developing resourcefulness than is gaining experience by watching experiments demonstrations. Intelligence and maturity do not seem to determine resourcefulness, a finding in accord with that of Beauchamp and Webb. C. M. P.

Looking ahead in professional development. W. K. LEWIS. *Chem. & Met. Eng.*, **44**, 680–1 (Nov., 1937).—A study of the industrial situation points to the conclusion that the demands which industry will make upon the engineer in the years immediately ahead will be far more severe, and, in many ways, different in character from the responsibilities placed upon him in the past.

Two changes in industry promise to be of outstanding significance. One of these is the sharply accelerated rate of development of processes and products. It reduces the time available for experimentation. It demands increased capacity for sound, fundamental analysis of highly complicated situations. The second problem is the rapidly increasing importance of the social factors of industrial work. It can only be mastered by engineers possessing an adequate grasp of both technical relationships and their social implications.

Our engineering schools must develop an educational program adequate for the future. Our present program in engineering is undoubtedly weakest with respect to the social sciences. The students must have practice in the art of human relationships. While laboratory instruction plays an important part in the engineering curriculum, it can never take the place of industrial experience.

The signs of the times point to the conclusion that the decades immediately ahead will offer the engineering profession potentialities for service of a quality and scope hitherto undreamed. J. W. H.

THE PHILOSOPHY OF EDUCATION

A serious charge. W. W. CHARTERS. *J. Higher Educ.*, **8**, 351–7 (1937).—Mr. Charters, Editor of the *Journal of Higher Education* and Director of the Bureau of Educational Research at Ohio State University says, "I agree in part with those teachers of subjects in colleges of liberal arts who maintain that the mastery of subject-matter is a sufficient training for teachers and that courses in education are chiefly thin collections of methods of instruction and administration which can normally be picked up on the job by an average teacher. I agree in part, but the point at which I part company is the assumption that this need be the case. If courses in education are bodies of superficial methods, it is the error of educators, but not the fault of education.

"Education has its unique and basic body of materials, just as the other professions have. Medicine specializes in a knowledge of the human body and engineering in the structure of materials. The special field of education is a knowledge of the human mind and particularly the minds of children. It is unfortunate that while a doctor-in-training spends 75 of 125 semester-hours in his four-year course on the anatomy, physiology, and pathology of the human body, a teacher-in-training devotes only 6 to 10 hours on psychology and educational psychology which deal with the anatomy, physiology, and pathology of the human mind. It is unfortunate that educators consider an understanding of the human mind of such slight importance, but assuredly it is not the fault of education that educators are not yet alive to the importance of this understanding. The need is vital, but they have not yet recognized it. Conditioned by one hundred years of laudable attention to improvement of scholarship and the theory and principles of teaching, an organization of one million members cannot respond instantly to a new combination of factors calling for new procedures and points of view.

"But however charitable one may be to the deficiencies of his brothers-in-the-craft, it yet remains that education is neglecting its fundamental bases. There is available today a huge body of materials in contributory fields which can easily be assembled for the required use of teachers, a body of knowledge without which teachers are less well equipped than nurses in the medical profession. They cannot by any stretch of imagination compare with the doctor, and that in spite of the fact that human psychology is more complicated and needs more artistry than human physiology." A. T. B.

Industrial contributions to employee education. W. L. ABRAMOWITZ. *Chem. & Met. Eng.*, **44**, 592 (Oct., 1937).—Many of the leading chemical and engineering concerns have already established definite programs whereby men are encouraged to attend night courses in nearby colleges and universities, the company sharing the expense. A percentage refund, which varies with the grade obtained in the course, is often made to the individual. Most companies allow a wide choice in courses that may be taken and do not insist unduly that subjects be intimately related with company interests.

For advanced men the summer school plan is finding increased favor. The men are thus liberated from the pressure of normal routine and become free to become engrossed in new developments as well as make new contacts and friendships.

A more unusual plan is where the companies pick exceptional men from their own staffs and send them to graduate school on a fellowship. The men generally work on problems of interest to the firm but still ones of a fundamental nature.

A few companies have found it preferable to have the men share their time between classroom and plant.

While there is some question as to the value of these schemes to the companies, most of them feel that this is a supplement, but not necessarily an alternative, to hiring high-priced men. A company which is progressive enough to contribute toward the education of its men need not fear for their loyalty. It is further felt that if a man is worth training and justifies the investment, it is not unreasonable to later raise his salary because of his increased training. J. W. H.

Education and divergent philosophies. W. F. RUSSELL. *Teachers Coll. Record*, **39**, 183–96 (Dec., 1937).—This is the annual report made to the Trustees of Teachers College. As Dean Russell phrases it "At Teachers College we have 'prance horses of pedagogy' and 'work horses' as well. We have theorists on our faculty—radical, conservative and all shades in between; and professors with divergent views often appear before the same class within the same period. Several 'prance horses' can run on the same educational track at the same time, trotters pacers, hunters, racers, even circus horses—all in one big unhappy family." The contrasting, sharply divergent technics, philosophies and curricula found in the Horace Mann School for Boys and the Lincoln School make this report an unusual tidbit. C. M. P.

RECENT BOOKS

A SHORT HISTORY OF CHEMISTRY. *J. R. Partington*, M.B.E., D.Sc., Professor of Chemistry in the University of London, Queen Mary College. The Macmillan Company, New York City, 1937. 13 × 20 cm. xiv + 386 pp. $2.50.

This is an excellent textbook, suitable for use in college courses in the history of chemistry and for collateral reading by students of chemistry and by students of intellectual history. It is written in a compact style, contains rather more information than some of the texts, and will serve, in general, as a book for first reference by teachers of chemistry who wish to look up the historical background for their lectures.

The author says in his preface, "The intention of the present work is to give a concise survey of the history of Chemistry, suited to the requirements of students preparing for degree examinations. The period before Boyle has been treated briefly, although greater prominence than usual is given to van Helmont on account of his undeniable importance. The development of Chemistry in the later part of the nineteenth and in the twentieth century is only briefly sketched and illustrated by the work of a few outstanding chemists; this part of the subject is dealt with the ordinary lecture courses on Chemistry and need not be repeated in a book of this kind. . . . . In subject matter also, an attempt has been made, by a careful division of topics, to find a better balance than has sometimes been attained. Most histories of Chemistry lay too much emphasis upon Organic Chemistry, and there are several special histories of this subject; more consideration has now been given to the important development of Physical Chemistry, no special history of which has yet appeared."

The first three chapters, treating respectively of The Origins of Applied Chemistry (Early Applied Chemistry, Early Knowledge of Metals, Glass, Dyes), of The Beginnings of Chemistry (The Four Elements, Chemical Knowledge of the Classical Period, The Chemical Papyri, Alexandria, The Beginning of Chemistry, Alexandrian Chemistry) and of The Diffusion of Alchemy (Chemistry in Arabia, Hindu Chemistry, Chemistry in China, Alchemy in Europe, Early European Writers on Alchemy, Roger Bacon, Arnald of Villanova, Raymund Lully), occupy forty pages and bring the history to the time of Paracelsus. They seem to the reviewer to constitute an inadequate treatment of the early period, and fail to give sufficient account of the results which the recent research of scholars of various nations has produced. This is all the more curious because of Partington's well-known interest in early chemistry and of the notable contributions which he has made to our knowledge of it. Yet it is probably true, after all, that the present brief treatment of the early period is sufficient to fulfil the author's objective of meeting "the requirements of students preparing for degree examinations." It is, however, not enough to meet the requirements of students who wish to get as liberal an education as possible out of their study of science. The cultural value of the history of early chemistry is large. Concerned with a time when the various intellectual disciplines were not yet separated, it brings the student in contact with the whole idea system of an ancient people, out of which system ideas, chemical and non-chemical, have been transmitted —transmitted by the processes of history which the student may thus see at work—separated, revised, re-combined or held separate; and these are the ideas which influence our present life in innumerable ways in chemistry and out of it. A study of the logical structure of ancient doctrines, of the morphology of dead beliefs, may be made without prejudice, and will help the student to evaluate fairly the opinions which prevail at present.

Chapter IV deals with Iatrochemistry, or Chemistry in the Service of Medicine (Paracelsus, Van Helmont, Sylvius, Agricola, Basil Valentine, Libavius, Glauber, Lemery, Tachenius, Kunckel) and terminates with a brief tabular Summary of the Early History of Chemistry. Chapter V, Early Studies on Combustion and the Nature of the Atmosphere, describes the work of Boyle, Hooke, Mayow and Jean Rey, and includes a short account of the philogiston theory of Becher and Stahl. Chapter VI treats of the Discovery of Gases (Hales, Black, Cavendish, Scheele, Priestley), and Chapter VII of Lavoisier and the Foundations of Modern Chemistry. Chapter VII and all those which follow it contain Summaries and Supplements which greatly increase the scope and value of the book. In Chapter VII the author says, "In this, and further summaries, the broad outlines of the work of each of the chemists dealt with in the text are summarized, and the opportunity is often taken of giving a brief mention of other chemists, or of work done by those dealt with in the text, in addition. The summaries are, therefore, in some ways an addition to the chapters and should not be passed over by the student. Summaries of topics are also given for the purpose of correlating information given in different places in the text."

The remaining Chapters, headed respectively, VIII, Laws of Combining Proportions and the Atomic Theory; IX, Davy and Berzelius and the Electrochemical or Dualistic Theory; X, The Beginnings of Organic Chemistry; XI, Substitution, the Unitary and Type Theories; XII, The Theory of Valency; XIII, The Development of Organic Chemistry; XIV, The History of Physical Chemistry; XV, The Periodic Law; and XVI, The Structure of the Atom, are such that the student may learn chemistry as well as the history of chemistry from them. The Summaries are excellent. That at the end of Chapter XIII makes mention of twenty-six organic chemists, always with dates, and of many others who collaborated with them or worked in related fields. The Supplement of Chapter XIV similarly contains twenty paragraphs, each devoted to a single physical chemist and the field of his researches. The Supplement of Chapter XV, entitled, "The Development of Inorganic Chemistry," likewise contains fourteen paragraphs. The book ends with "A Short Bibliography" which "contains particulars of some works which may be consulted for further details, and also books on the History of Chemistry (of varying value)," and with name and subject indexes. It is fully illustrated.

The excellent textbook is attractive and moderately priced.

TENNEY L. DAVIS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
CAMBRIDGE, MASSACHUSETTS

LABORATORY TECHNIQUE IN ORGANIC CHEMISTRY. *Avery Adrian Morton*, Associate Professor of Organic Chemistry, Massachusetts Institute of Technology. McGraw-Hill Book Company, Inc., New York and London, 1938. x + 261 pp. 14 × 21 cm. $2.50.

LABORATORY TECHNIQUE IN ORGANIC CHEMISTRY presents a detailed and comprehensive consideration of the basic principles of organic technic. One complete chapter is devoted to each of the following basic procedures: drying and drying agents, the melting point, the boiling point, fractional distillation, vacuum distillation, steam distillation, crystallization, filtration, adsorption, extraction, and special methods and apparatus. Eighteen experiments in the back of the book are designed to familiarize the student with micro-boiling points, micro-fractionation, micro-sublimation or distillation under vacuum, fractionation, drying or esterification with a fractionating column, vacuum distillation, vacuum distillation of very small quantities, molecular distillation, super-heated steam distillation, purification by digestion, chromatographic adsorption, the cooling curve, purity and identity from the boiling point, filtration, crystallization of lactic acid and sirupy mixtures, determination of the number of theoretical plates in a fractionating column, reaction in an inert atmosphere, and macro experiments.

Twenty pages are devoted to a consideration of *drying and drying agents*, which is subdivided into (a) chemical agents, (b)

physical agents, and (c) relative efficiencies of drying agents. Under the *chemical agents* the respective merits of magnesium perchlorate, barium perchlorate, calcium chloride, magnesium chloride, calcium bromide, calcium sulfate, copper sulfate, sodium sulfate, aluminum sulfate, potassium carbonate, calcium oxide, barium oxide, aluminum oxide, phosphoric anhydride, boric oxide, sulfuric acid, caustic alkalies, and the alkali and alkaline earth metals are considered in some detail. Under *physical agents* the author discusses fractionation, binary and ternary mixtures, drying with the aid of constant boiling mixtures, the application of heat as a drying agent, the use of freezing to remove moisture, adsorption, absorption, and extraction. Five tables are utilized to display the *relative efficiencies of drying agents*.

In the twenty-nine pages dealing with the *melting point*, the author considers the necessity of clean tubing, the rate of heating, the relation of purity to the melting point, mixed melting points and the two possible exceptions, decomposition at the melting point, multiple melting points, relation of melting points to structure, apparatus, copper blocks, thermometers, micro methods, the curve method, the heating curve, and apparatus and manipulation.

The twenty-two pages on the *boiling point* deal with micro methods, macro methods, thermometers, the differential thermometer, the boiling point as a criterion of purity, determination of purity or identity, and constant-boiling mixtures in the syntheses, separation, and purification of organic compounds.

Fractional distillation, to which twenty-five pages are devoted, is considered under the subheadings: micro and semi-micro scale, factors in the design of a column, nature of the packing, ring packing, reflux ratio, length of the column, measurement of the efficiency of a column, and fractionating columns.

Twenty-five pages are used in a discussion of *vacuum distillation technic* under the subheadings: size and position of side-arms, stoppers, bumping manostats, receivers, pumps, gages, fractionation under vacuum, and the molecular still.

In the chapter on *steam distillation* the author considers compounds insoluble in water, compounds soluble in water, the effect of salt, volatility of ortho-substituted compounds, apparatus and procedure, steam distillation at reduced pressure, co-distillation, and superheated steam. Twenty-three pages are devoted to steam distillation.

In the twenty-three pages on *crystallization* are considered the effect of purity of the compound, choice of a solvent, the effect of cooling, the effect of surface, the influence of fluidity, seeding, scratching and rubbing, radium emanations, effect of symmetry of the molecule, equation for velocity of crystallization, overcoming difficulties in crystallization, fractionation by crystallization, and creeping.

Filtration, covering fifteen pages, deals with micro-filtrations, macro-filtrations, filtration of hot liquids, low temperature filtrations, and the centrifuge and its use.

The chapter on *adsorption* covers eighteen pages and considers sources of carbon, nature of substances adsorbed, effect of solvents, effect of the pH of the medium, the equation for adsorption, manner of adsorption, decolorization with other substances, and the general principles, adsorbents, solutions, apparatus and manipulation, and applications of chromatographic adsorption.

In the chapter on *extraction*, covering fifteen pages, one reads about single extraction, effect of solvent, effect of hydrolysis of salts, analysis by extraction, similarity of extraction and distillation processes, apparatus for continuous extraction of solids, and continuous liquid-liquid extractions.

Ten pages are devoted to *special methods and apparatus* under the subtitles micro-manipulation, sublimation, agitation, and reactions in inert atmospheres.

The book is well illustrated by the use of one hundred twenty-two figures dealing with graphs and drawings of apparatus, and the theoretical discussions are exemplified by the aid of sixty-five tables.

One has the feeling, after carefully scanning the pages of this manual, LABORATORY TECHNIQUE IN ORGANIC CHEMISTRY, that it is a distinctly valuable compilation of the available material on organic technic. Both graduate and research students should find the book to be extremely helpful as a standard reference on technic practices in organic chemistry.

ED. F. DEGERING

PURDUE UNIVERSITY
LAFAYETTE, INDIANA

THE ADVANCING FRONT OF SCIENCE. *George W. Gray.* Whittlesey House, McGraw-Hill Book Company, New York City, 1937. xiv + 364 pp. 22.5 × 14.5 cm. $3.00.

The book is an attempt to report news, rather than to summarize history; it outlines a course in recent advances in science written for the layman. Its sixteen chapters embrace the fields of astronomy, biology, chemistry, physics, and psychology. Listed in order, the chapters of the book deal with new horizons in scientific research; the reflecting layers of the atmosphere and radio communication; dwarf stars, giant stars, and double star formation; the troublesome red shift of spectral lines; recent development in sensitizing photographic emulsions and their applications to astronomical research; cosmic rays, their intensity and disputed nature; nuclear penetration and the breaking down of Coulomb forces within the nucleus; a discussion of the science of sound with practical applications to eliminate reverberation; recent applications of chemistry in getting bromine out of sea water, producing new resins, alloys, fuels, etc.; the work of Irving Langmuir; recent theories of photosynthesis and the hypothetical mitogenetic rays; investigations with genes and chromosomes and new border lines between the living and nonliving; the work of Carrel and Lindbergh, new science of mathematical biophysics; thinking machines which illustrate highly simplified human behavior; recent advances in physiology; possibilities of lengthening the span of life, the effects of vitamins, and wonders of controlled evolution.

The scope of the book is such that only those experiments which will leave a high-water mark on the history of science are discussed. Besides the discussion of scientific progress of the period during which science was on "short rations," the book contains numerous biographical details and laboratory "asides" of the men whom the author interviewed in gathering the material for the book. However, in one chapter the biographical details have become so numerous and inclusive that the subtitle could well be given "The General Electric Research Laboratory and the Life of Irving Langmuir." Concerning the two chapters on chemistry, it may be said that the author fell short of his mark, and instead of reporting the news, has recorded history. In the second of these two chapters the following statement is met with, describing the result of some experimental work, "This improvement is yielding the American public an average nightly saving of $1,000,000 on its electric-light bill." This statement savors of newspaper advertisements and popular radio programs.

The reports on physics and astronomy have been made more faithfully. The recent work of the atom smashers has been vividly outlined in non-technical language. An interesting chapter is that dealing with the troublesome red shift of spectral lines. The possible explanations of this phenomenon are unmasked of mathematical intricacies, which makes readable material for the layman.

It is difficult, however, to conceive that the book as a whole can be understood by the average layman without some sort of scientific background—at least more in content and clearness than that which our great populace gets from the Sunday papers and radio programs. Throughout the book the author has used terms and phenomena which are familiar only to those who have had an introduction to science. In the opinion of this reviewer the book is excellent reading to such an individual; it is also highly recommended as collateral reading for science survey courses.

The author succeeds in bringing a disconnected news report from the outposts of scientific research. The reports are given in excellent style and with far more integrity than the usual science feature stories. The reports, however, of any advance or

conquest carry with them a certain amount of enthusiasm or optimism. Of these the author has more than an ordinary dose. The effects of scientific advances on the mental progress of our society are such that a realist finds it difficult to sustain this enthusiasm.

NICHOLAS D. CHERONIS

CHICAGO, ILLINOIS

ELEMENTARY EXPERIMENTAL CHEMISTRY. *John C. Hogg*, M.C., M.A., Chairman, Science Department, Phillips Exeter Academy, and *Charles L. Bickel*, A.M., Ph.D., Instructor in Chemistry Phillips Exeter Academy. Oxford University Press, New York City, 1937. ix + 288 pp. 42 figs. $2.00.

The purpose of the book as stated in the preface is to provide material for the laboratory teaching of an elementary course in chemistry, a course independent of the textbook to stimulate clear, independent, and original thinking.

The content of the book, consisting of forty-two exercises, is divided into three parts (Parts I, II, and III). The work of Part I includes a study of the Bunsen burner, the manipulation of glass, a study of the chemical balance, and a group of elementary quantitative experiments. Part II contains a fine selection of experimental exercises more commonly found in high-school laboratory manuals. In Part III, as the authors suggest, are "less important experiments" which offer a wider variety of approach. The abundance of material should make possible the achievement of the authors' purpose, if sufficient time is available to permit of an extensive sampling by the students. Undoubtedly many chemistry teachers will be disturbed by the departure from the conventional experiments which are synchronized with a textbook.

The general plan of the book is excellent, and the subdivision of the work into short units (experiments) will certainly result in a more profitable expenditure of student time in the laboratory. The introduction to each exercise is invaluable, especially if a textbook is not used in conjunction with the laboratory work.

The authors have not made clear the field for which ELEMENTARY EXPERIMENTAL CHEMISTRY is intended, and it is possible that the average high-school teacher may be somewhat confused about it. If the laboratory manual is intended for use by beginning high-school classes in chemistry, then considerable difficulty and confusion may result in attempting Exercise 4 so early in the work. In fact, in the Introduction (page 25 to this piece of work) the authors refer to the prediction of reactions by reference to the replacement series.

The emphasis on quantitative work in Part I, while very interesting and profitable to the student, may render the book unusable in many schools because of lack of equipment. Many schools, excepting the technical schools, do not have balances and other apparatus to meet the needs of large classes.

It is unfortunate that in such a fine piece of work, it is necessary to draw attention to a few examples that seem to be out of accord with the general content of the book. On page 53, the use of pH to indicate hydrogen pressure may result in confusing the student later with pH values. Again, on page 95, Experiment 4, "Ammonia By Friction," is a good example of a low-temperature reaction. Just holding the material in the hands without friction produces excellent results. Then on page 108, the use of ammonium hydroxide on the skin as an "antidote" for nitric acid may cause further irritation of the skin. Some very painful results have followed the application of ammonium hydroxide to the surface of the body.

The actual content of the book is not as great as the two hundred eighty-eight pages might suggest, since the pages are printed on one side only. This plan is used in order to enable the student to transfer pages from the laboratory manual to a notebook. The use of the blank pages for notes instead of removing direction sheets to a notebook would keep the notes intact in the laboratory book with the explanatory material.

The book represents a real contribution in the field of elementary chemistry at a time when the place of pure science is becoming somewhat unstable and there seems to be a tendency toward the vocationalized science in which demonstrations and "movies" are substituted for laboratory.

K. M. PERSING

GLENVILLE HIGH SCHOOL
CLEVELAND, OHIO

OUTLINES OF THEORETICAL CHEMISTRY. *Frederick H. Getman*, Ph.D., formerly associate Professor of Chemistry in Bryn Mawr College, and *Farrington Daniels*, Ph.D., Professor of Chemistry in the University of Wisconsin. Sixth edition. John Wiley and Sons, Inc., New York. 1937. ix + 662 pp. 170 figs. 15 × 23 cm. $3.75.

This text is so well known that extensive discussion of its purpose and makeup is unnecessary. Inspection of the sixth edition leaves one with the distinct impression that the book has undergone a thorough "housecleaning," yet with each "piece of furniture" in its accustomed place, although "reupholstered." To former users it will be perfectly familiar, but even more inspiring than before. It is a masterpiece of revision that combines the worth-while new ideas without sacrifice of time-tried concepts and logical presentation.

Yet the new edition is but nineteen pages larger than the old. This economy of space has been secured in two ways. First, description of experimental technic has been minimized, since good laboratory manuals are legion. Second, many derivations are combined in a small type appendix. They are more numerous and more detailed than before. Reference is made to this appendix wherever an equation, so derived, is used.

As implied, the revision is so skillful that one has difficulty in picking out the obviously new features. Noteworthy among these is a short section on electron diffraction, a chapter on molecular structure, and the discussion of fundamental thermodynamic concepts and functions as suggested by W. E. Roseveare (to be published in THIS JOURNAL).

Each chapter concludes with an excellent set of problems. These are, to a great extent, new and are divided into two or three groups. To the first set, answers are given, to the second set none. With some chapters a third set presents problems requiring more independence of thought and effort than is common. The instructor has thus considerable latitude in his assignments. Numerous references to specialized works precede the problems.

As stated, the arrangement follows previous editions, the principal changes occuring among the last chapters. Quantum mechanics now precedes photochemistry. Radioactivity has been promoted to neuclear structure. The electrical theory of matter has been merged into the chapter on atomic structure. Tables, graphs, and figures are slightly less numerous, but more up-to-date.

Novel and useful additions are an appendix on mathematical formulas, an appendix on symbols used throughout, an index giving quantitative relationships associated with names, and a 4-place table of logarithims. The format has the excellence associated with Wiley books.

Two things might be improved. First, a brief discussion of dimensional formulas, and possibly units, would add to the value of the book. Second, the MacInnes formula for the liquid junction potential has been omitted and the Lewis and Sargent formula lacks definition. As written (page 438) it applies to the case of a common cation. A statement that the sign is negative for a common anion would correct matters.

The publishers have found it necessary to issue an Errata sheet to be pasted in the book. About fifty errors, mostly minor and obvious, are noted. This is regrettable but understandable in view of the time considerations involved.

In conclusion, the authors are to be commended on a really excellent text. It can be heartily recommended to all students and teachers of the subject. Old friends will need no urging to consider the sixth edition.

MALCOLM M. HARING

UNIVERSITY OF MARYLAND
COLLEGE PARK, MARYLAND

Series of Organic Compounds

TO demonstrate similarity in reactions of homologues... to show the properties of straight or branched chains... to indicate the effect of substituted groups in various positions. These are some of the uses for which complete series of organic compounds are valuable.

Included among the 3,100 compounds in List No. 28 of *Eastman Organic Chemicals* are many such series of both aromatic and aliphatic groups. A free copy of this list will be forwarded upon request. Eastman Kodak Company, *Chemical Sales Division,* Rochester, N. Y.

EASTMAN ORGANIC CHEMICALS

Two Outstanding New Books *for* Chemistry Teachers

FOWLES—Lecture Experiments in Chemistry

150 Illustrations. Tables. Appendices. 564 Pages $5.00
By G. Fowles, M.Sc., A.I.C., F.C.S. (Latymer Upper School, Hammersmith, Lond.)

"This book contains 547 experiments of every conceivable type and gives clear and concise directions for performing them and adds, in many cases, excellent teaching material, setting forth the principles involved in the reactions. An appendix gives a study of the various methods of teaching and gives a brief account of the manner of lecturing by many famous lecturers. Mechanical aids to lecturing are also discussed. No college lecturer can afford to be without this manual and many high-school chemistry teachers could find much material to enrich their courses in its pages as well as some very fine instruction in the art of teaching."—School Science and Mathematics.

HACKH—Chemical Dictionary. 2nd Edition
With Pronunciation

Revised. Enlarged. Illustrated. 1020 Pages. Washable Cloth $12.00
By Ingo W. D. Hackh, A.M., F.A.I.C., F.R.S.A. (San Francisco) With Collaboration of Julius Grant, M.Sc., Ph.D., F.I.C. (London)

This is a modern dictionary of all of chemistry. It presents the theories, laws, rules; describes elements, compounds, drugs, minerals, vegetable and animal products; lists reactions, processes, methods, apparatus, equipment, etc. This edition contains 10,000 new items, 230 additional pages making a total of 50,000 words with pronunciation indicated.

Order----------

P. BLAKISTON'S SON & CO., INC. 1012 Walnut Street, Philadelphia, Pa.

Send me the following book and charge my account.

☐ *Fowles*—Lecture Experiments $5.00
☐ *Hackh*—Chem. Dictionary, 2nd Ed. $12.00

Name .....

School.....Address.....

J.C.E. 4-38

TRADE ANNOUNCEMENTS

The Compton Chart

This new chart is a distinct contribution to the teaching of modern science. It displays graphically, in connection with the great wave gamut, the fundamental facts and theories regarding the ever-expanding, dynamic field of electromagnetic radiations. It is a veritable textbook which leads one logically from the simple laws and well-known characteristics to the current concepts of the ultimate nature of matter with its attendant basic relationship of energy and mass. The student is led from the easily demonstrated laws of the electric generator to the nucleus of the uranium atom and the most recent studies of cosmic rays and particles. The chart may be obtained from the *W. M. Welch Scientific Co., 1515 Sedgwick Street, Chicago.*

Solution Control for Electroplating

A brief review of electroplating, discussing the present need for scientific analytical control, is contained in a new service bulletin on "Solution Control for Electroplating" just issued by the *Grasselli Chemicals Department* of *E. I. du Pont de Nemours & Company*. Old methods were rapidly changed when industry demanded uniform results on large scale operations and when new processes were introduced that were not operative without accurate chemical control, explains the bulletin, which adds,

"While some new analytical methods were required, most determinations for all plating process control could be made under existing methods in common use by all chemical laboratories. These methods were not always available to the manufacturer or individual operating a plating plant and were rather long and complicated, requiring considerable costly chemical equipment and the services of an experienced analyst. The cost was consequently prohibitive, except to the larger manufacturers.

"With the advent of large-scale production of electroplated products, the manufacturer found it necessary to use the same careful control of plating processes as with other chemical, metallurgical, and mechanical operations. The smaller manufacturer or electroplater in the face of more exacting specifications was placed at a disadvantage without such control, but could hardly afford the expense it entailed. Adaption of methods of chemical analyses and control to electroplating processes by simplifying the equipment or apparatus required and modifying the methods and couching them in such terms that a chemical training would not be a prerequisite for their use was the natural outgrowth of this large scale production. That this has been successful is shown by the wide use of simple control methods for nickel plating solutions alone. Without them, bright nickel and chrome plating would be almost an impossibility. With them, definite, consistent results at lower costs can be obtained.

"*The Grasselli Chemicals Department* has recognized, from the time it entered the electroplating field, the importance and value of close analytical control of electroplating solutions. Only by such measures can consistent results be secured. This department has maintained an analytical service for its customers through which they could obtain complete analyses and tests of the various plating solutions under its jurisdiction. This service consisted of, first, accurate analyses of the solution samples; second, correction of the samples and coincident plating tests; and third, recommendations to its customers for the necessary additions to, or changes of, the solution to place it in the best operating condition.

"While the results of such a service have been very gratifying, it has also been recognized that this form of service is subject to serious objection. Considerable time must elapse between the time the sample is taken from the plating tank and the time the solution is corrected. This delay, undoubtedly, could easily be tolerated with the old-time, low-current-density solution, but in the modern, fast-plating electrolyte where, not on a basis of production but on a basis of time, changes of composition take place more rapidly, it is apt to cause difficulties and irregularities in the character of the deposited metal.

"To eliminate this difficulty, to avoid this delay, and to provide a means, not of correction, but of control of a plating solution has been the purpose in developing the simplified tests for the control of cyanide, cadmium, and zinc plating solutions. By their use any irregularities in solution composition may be detected and corrected before they are evident in the deposits obtained. This company believes it has been successful in reducing the rather complicated and elaborate laboratory methods of analysis for cadmium and zinc cyanide plating solutions to a simplified form capable of giving satisfactorily accurate results in the hands of the layman."

Hager Separator

The Hager Separator is manufactured by the *Textite Corporation, 2110 Roscoe Street, Chicago, Illinois*. Its concentrated cleaning action costs nothing to operate because pressure of an element passing through the separator provides all the cleaning action necessary. Cleaning separation is obtained by linear deflection, jetting, centrifugal force, capillary attraction, and sudden expansion.

Mounted one above the other in this new separator are three internal vaned units through which the air, gas, or steam must travel in succession before it can issue at the top connection. Each of these units sets up a rapid whirling movement in the element as long as there is passage through the separator. The whirling throws moisture and dirt outward from the center. At the same time the flow is caught by additional sets of vanes curved in the opposite direction and secured to overlapping sleeves inside the housing. The reversal following the centrifugal action causes the moisture and dirt to strike the inner surface of the cups from where they drop to a collection chamber just inside the shell of the assembly. Flow from outlet is clean and dry.

The separator now being manufactured is suitable for pipe sizes to $^{3}/_{4}$ inch. It is made with a tie-rod assembly of heads and shell, so that the inside is easily accessible for examination. There is no wearout to parts because cleaning units remain stationary. Metals used in construction are rust-proof and acid-resisting.

"Abopon," New Sealer Developed

A new sealer known as ABOPON has been developed by the *Glyco Products Co., Inc., 148 Lafayette Street, New York City.* ABOPON is a clear, transparent, inorganic, non-inflammable odorless liquid which can be diluted with water and applied by dipping, brushing, or spraying. On drying, a transparent, colorless film is left on the surface which effectively seals the material. Thus, in general, only one or at the most two coats of the lacquer or other coatings are all that is required to give the desired effect. ABOPON can be used in exactly the same way to prevent penetration of oils and greases into paper and similar products.

Trade Literature

RESEARCH PUTS THE DIATOM TO WORK. *Johns-Manville Co., 22 East Fortieth St., New York City.* 24 pp. 15 × 23 cm.

CHEMISTRY SERVES THE SHIPPING INDUSTRY. *Bull & Roberts, 117 Liberty St., New York City.* 8 pp. 21.5 × 28 cm.

THE STORY OF NEOPRENE. *E. I. du Pont de Nemours & Co., Inc., Wilmington, Delaware.* 6 pp. 21.5 × 28 cm.

COKE PLANTS. *The Koppers Construction Co., Koppers Bldg., Pittsburgh, Pennsylvania.* 12 pp. 28.5 × 35.5 cm.

WESTINGHOUSE INSTRUMENTS. *Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pennsylvania.* 15 pp. 21.5 × 27.5 cm.

BOOK CATALOG. *Chemical Publishing Co. of New York, Inc., 148 Lafayette St., New York City.* 136 pp. 13.5 × 21 cm.